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VOLUME 51 APRIL 1965 NUMBER 2

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VOLUME 51 APRIL 1965 NUMBER 2

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OCCURRENCES OF THE LOST RIVER SUCKER, *DELTISTES LUXATUS* (COPE), AND SHORTNOSE SUCKER, *CHASMISTES BREVIROSTRIS* COPE, IN NORTHERN CALIFORNIA[1]

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The Lost River sucker and the shortnose sucker are added to the freshwater fish fauna of California. Their distribution, a brief discussion of habits, and meristic data are included.

Recent captures of the Lost River sucker and the shortnose sucker represent additions to the freshwater fish fauna of California (Shapovalov, Dill, and Cordone, 1959). The ranges of these suckers (family Catostomidae) previously were given as the Klamath Lakes drainage in Oregon (Schultz, 1936; Eddy, 1957). Gilbert (1898) stated that *Deltistes* apparently were resident during most of the year in the deeper waters of Upper Klamath Lake and Tule Lakes (Figure 1).

On May 15, 1955, Ned Dollahite, California Department of Fish and Game, collected a mature shortnose sucker from Boles Creek, Modoc County, near Steele Swamp Ranch. I saw additional specimens in the same vicinity on May 10, 1960, which were swimming upstream in an apparent spawning migration. Boles Creek is an intermittent tributary of Willow Creek, the principal stream entering Clear Lake Reservoir. Lost River originates from Clear Lake Reservoir, flows northward into Oregon, eventually re-enters California, and discharges into Tule Lake, its natural terminus. Lost River is now connected to the Klamath River by the Lost River Diversion Canal.

Specimens of the shortnose and Lost River suckers were first collected from Copco Lake, Siskiyou County, on November 20, 1956. Both species were noted in a routine beach seine haul. Copco Lake is a storage reservoir on the Klamath River near the Oregon border. The collection site was a gently sloping beach with a maximum depth of about 6 feet. The bottom consisted of silt and coarse gravel, interspersed with submerged logs. Three Lost River suckers were 19.3 to 27.4 inches long (fork length) and weighed 4.7 to 11.1 pounds. Four shortnose suckers were 17.3 to 20.1 inches fork length and weighed 2.6 to 3.1 pounds. Later sampling at the same locality, with beach seines and gill nets, usually revealed both species, particularly in the fall, but I have never seen young or evidence of spawning activity by these peculiar suckers in Copco Lake.

[1] Submitted for publication September 1964.

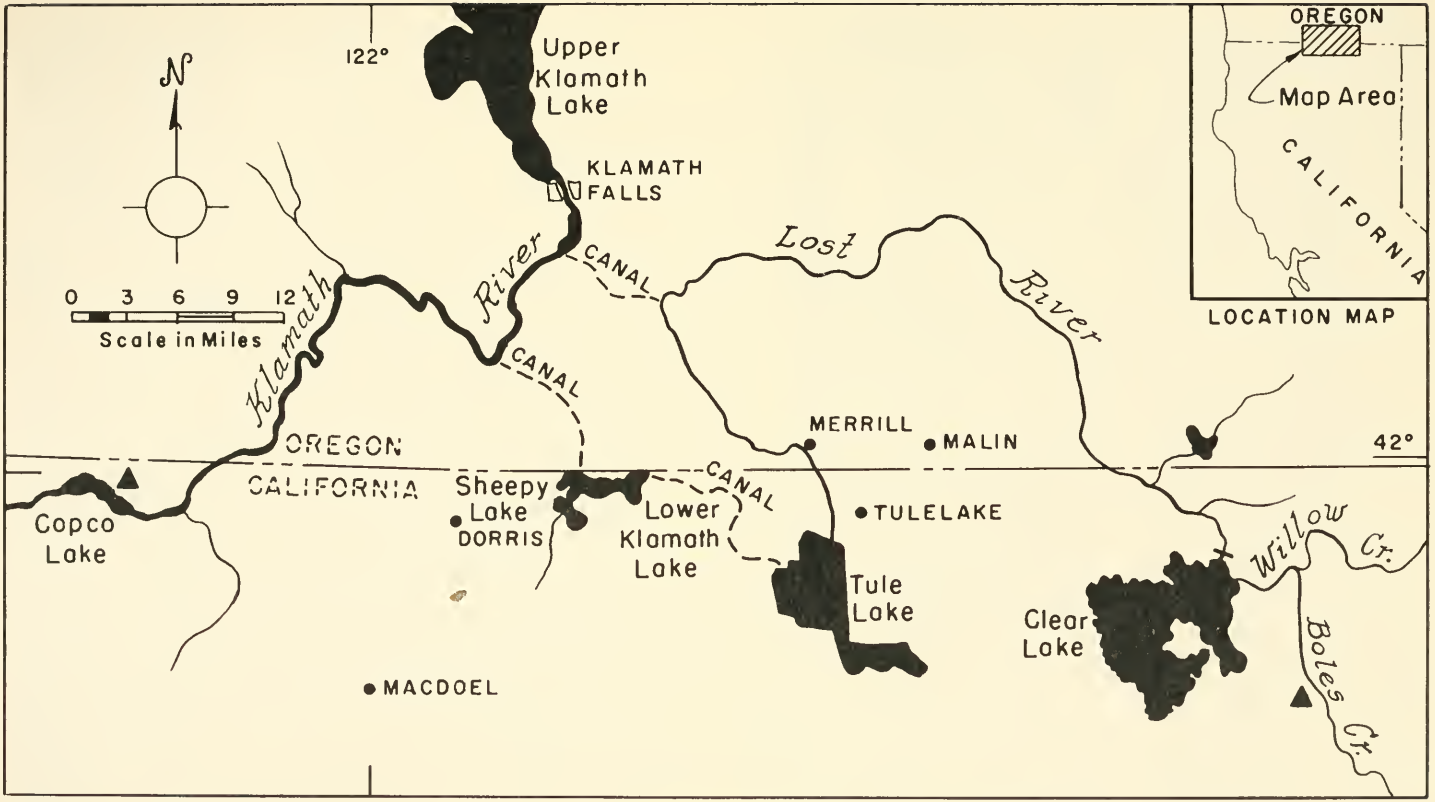

FIGURE 1. Map of the Klamath and Lost Rivers in Oregon and California, showing collecting localities (black triangles) for suckers.

I mailed the head of a Lost River sucker and photographs of shortnose suckers from Copco Lake to Carl E. Bond, Oregon State University, who verified the identity of both species. I shipped three specimens of *Deltistes* and one of *Chasmistes* to the California Academy of Sciences, San Francisco; and W. I. Follett, Curator of Fishes, and Merton Ball kindly provided meristic data on them (Tables 1 and 2).

TABLE 1

Counts and Measurements of the Three *Deltistes luxatus* From Copco Lake, Siskiyou County, California (California Academy of Sciences No. 26304)

	Adult female (skeletonized)	*Adult (preserved)*	*Adult (preserved)*
Total length (inches)	30⅛	28	26⅜
Standard length (mm)	663	585	575
Weight (pounds)	9⅞	6⅛	7
Dorsal rays	12	12	11
Anal rays	7	7	8
Pectoral rays	16–15	17–17	16–16
Pelvic rays	10–10	10–10	10–10
Principal caudal rays (branched rays +2)	9+ 9	9+ 9	9+ 9
Lateral-line pores	88–88	84–85	86–82
Gill rakers	32–32	-----	-----
Vertebrae	29+22=51	-----	-----

TABLE 2

Counts and Measurements of an Adult Female (Skeletonized) *Chasmistes brevirostris* From Copco Lake, Siskiyou County, California (California Academy of Sciences No. 26305)

Total length (inches)	17½
Standard length (mm)	374
Weight (pounds)	2¾
Dorsal rays	11
Anal rays	7
Pectoral rays	17–17
Pelvic rays	10–10
Principal caudal rays	9+ 9
Lateral-line pores	79–78
Gill rakers (second arch left side)*	39
Vertebrae	27+19=46

* Gill rakers on right side had been removed for identification.

Deltistes is distinguished by its large size, reaching 3 feet as adults (Eddy, 1957). The head is long and slender with a slight hump on the upper surface of the snout. The mouth is terminal and oblique. The lips of several specimens from Copco Lake bore minute papillae. The gill rakers are triangular and their edges are generally unarmed and entire. The scales are large, as much as 12 mm at the widest diameter in the larger specimens.

The head of *Chasmistes* is comparatively small. The hump on the short snout formed by the premaxillary spines was prominent in some of the Copco Lake specimens, and to a lesser degree in others. The mouth is oblique with no papillae on the thin lips. The free margins of the triangular gill rakers are fringed with fine teeth. The body is more cylindrical than the Lost River sucker (Figure 2). The numbers of eggs in the ovaries of two *Chasmistes* from Copco Lake, calculated by the displacement method (Burrows, 1951), were 36,763 and 56,217. Both specimens measured 19.3 inches fork length.

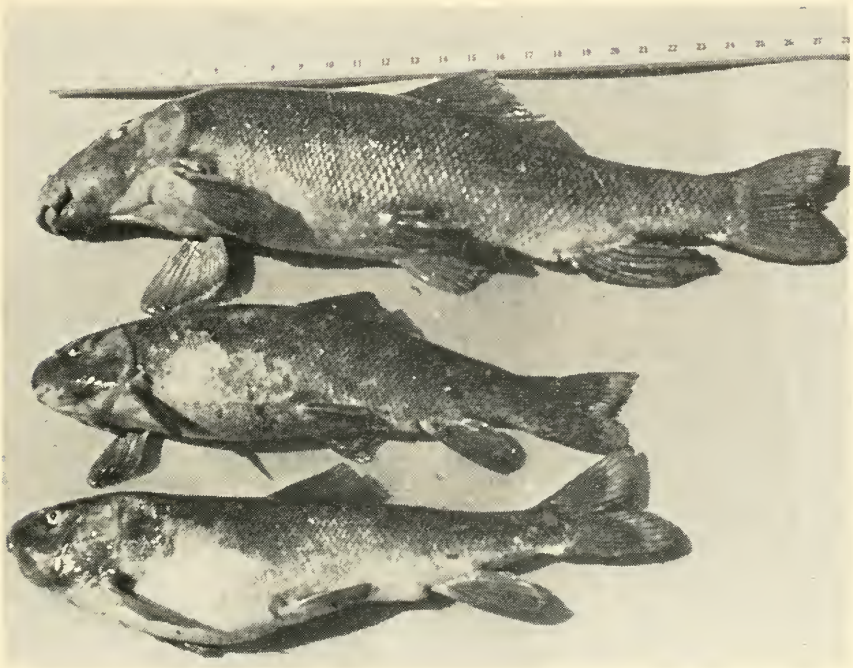

FIGURE 2. Lost River (upper) and shortnose suckers (center and lower) from Copco Lake, Siskiyou County. *Photograph by Millard Coots.*

The shortnose suckers, reported by Cope (1879) as abundant in Upper Klamath Lake, Oregon, now might be less plentiful. Carl E. Bond (pers. commun., dated November 27, 1957) said he had difficulty obtaining specimens of *Chasmistes* from Upper Klamath Lake.

No definite conclusions on age could be drawn from scales of several specimens of both species from Copco Lake. The usual characters for determining annual growth such as "cutting over," packing of the circuli, and irregularities associated with changes of scale growth were confusing and variable. Some scales lacked bands of spaced circuli, and in others the peripheral area was so jumbled that interpretation was impossible. Distinct concentric bands on opercular bones, which could represent annual growth, usually showed no relationship to scales from the same specimens.

Suckers of the genus *Chasmistes* also occur in two remnant Pleistocene lakes of the Great Basin: the June sucker, *C. liorus,* of Utah Lake, Utah, in the Bonneville drainage, and the cui-ui sucker, *C. cujus,* of Pyramid Lake, Nevada, in the Lahontan drainage. The close relationship of various genera of fishes such as *Chasmistes* and *Siphateles* in the upper part of the Klamath drainage and the Great Basin suggest a past connection with the interior basin (Gilbert, 1898; Hubbs and Miller, 1948; Robins and Miller, 1957).

The nomenclature of the Lost River sucker, which has been mentioned as related to the genus *Chasmistes* (Hubbs and Miller, 1948), has changed since being first described by Cope (1879) as *Chasmistes*

luxatus. Eigenmann (1891) proposed the name *Catostomous rex* based on the characters of a 32-inch specimen. Based principally on a difference in the form of the gill rakers from *Chasmistes*, Seale (1896) described the fish as *Deltistes luxatus*. This species was recently designated *Catostomous luxatus* (Amer. Fish. Soc., 1960).

In his original descriptions of the Lost River and shortnose suckers, Cope (1879) mentioned that the Lost River sucker was taken and dried in large numbers by the Klamath and Modoc Indians. The Klamath Indians called the *Deltistes*, "*Tswam*," and the *Chasmistes*, "*Xooptu*." The Lost River sucker now provides a sport fishery in the spring, principally around the margins of Upper Klamath Lake, Oregon. The fish, locally called "mullet," are usually caught by snagging with grabhooks during their spawning runs in the vicinity of springs and the lower reaches of tributary streams. The flesh is somewhat coarse but has a pleasant flavor (Van Wormer, 1955).

Evidence that the Lost River sucker once populated both Tule Lake and Lower Klamath Lake in California is substantiated by statements from long-time residents in that vicinity. Lewis Foulke, a retired rancher from Yreka, Siskiyou County (pers. conversation on February 24, 1963) remarked that he observed large suckers and rainbow trout, *Salmo gairdneri*, being taken from the mouth of Lost River about 1919. Set lines and snagging gear were used. On March 6, 1963, I discussed the status of sucker populations in Lower Klamath Lake with John McKay, who lives near Dorris, Siskiyou County. He stated that the Lost River sucker formerly populated Sheepy Lake and spawned in Sheepy Creek, a short spring-fed stream. Sheepy Lake, a western extension of Lower Klamath Lake, is in the Lower Klamath National Wildlife Refuge. According to McKay, local residents took large numbers of fish in the spring, especially from the "Sucker Hole" in the creek. They used chicken wire traps and snag gear. The catches were utilized for human consumption and hog feed. The fishery continued until sometime before 1924, when thousands of acres of lakes and marshland in the Lower Klamath-Tule Lake area were drained and converted to farmland. McKay stated the reclamation of Sheepy Lake resulted in a heavy mortality of fish, including the large suckers. After futile efforts to farm the lake beds, Lower Klamath Lake—including Sheepy Lake—was reflooded (Miller and Collins, 1953). On March 6, 1963, I questioned Joseph Allen, a former Siskiyou County Supervisor, whose ranch adjoins Sheepy Creek, on the fishes of Sheepy Creek. Based on his observations of a few large fish in the creek in the spring of 1960, he believes that a remnant population of Lost River suckers possibly spawns in Sheepy Creek.

REFERENCES

American Fisheries Society. 1960. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc., Spec. Publ. 2, 102 p.

Burrows, R. E. 1951. A method for the enumeration of salmon and trout eggs by displacement. Prog. Fish-Cult., 13 (1) : 25-30.

Cope, Edward Drinker. 1879. The fishes of Klamath Lake, Oregon. The Amer. Nat., 13 : 784-785.

Eddy, Samuel. 1957. How to know the freshwater fishes. Dubuque, Iowa, Wm. C. Brown Co., 253 p.

Eigenmann, Rosa Smith. 1891. Description of a new species of *Catostomous (C. rex)* from Oregon. The Amer. Nat., 25 : 667-668.

Gilbert, Charles H. 1898. The fishes of the Klamath River Basin. Bull. U.S. Fish. Comm., 17 (1897) : 1-13.

Hubbs, Carl L., and Robert R. Miller. 1948. The Great Basin with emphasis on glacial and postglacial times. Correlation between fish distribution and hydrographic history in the desert basins of Western United States. Univ. of Utah, Bull., 38 (20) : 17-166.

Miller, A. W., and B. D. Collins. 1953. A nesting study of Canada geese on Tule Lake and Lower Klamath National Wildlife Refuges, Siskiyou County, Calif. Calif. Fish and Game, 39 (2) : 385-396.

Robins, C. Richard, and Robert Rush Miller. 1957. Classification, variation and distribution of the sculpins, genus *Cottus*, inhabiting Pacific slope waters in California and Southern Oregon, with a key to the species. Calif. Fish and Game, 43 (3) : 213-233.

Seale, Alvin. 1896. Note on *Deltistes*, a new genus of catostomoid fishes. Calif. Acad. Sci., Proc., 6 : 269.

Schultz, Leonard P. 1936. Keys to the fishes of Washington, Oregon, and closely adjoining regions. Wash. Univ., Publ. Biol., 2 (4) : 103-228.

Shapovalov, Leo, William A. Dill, and Almo J. Cordone. 1959. A revised checklist of the freshwater and anadromous fishes of California. Calif. Fish and Game, 45 (2) : 159-180.

Van Wormer, Joseph. 1955. The mysterious mullet of Klamath Lake. Sports Afield, March 1955, p. 63-65.

Calif. Fish and Game, 51(2) : 74–80. 1965.

EARLY DEVELOPMENT OF THE HITCH, *LAVINIA EXILICAUDA*, OF CLEAR LAKE, CALIFORNIA[1]

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In 1962 and 1963, eggs were collected from hitch during their spawning in tributaries of Clear Lake. The eggs were hatched using improvised hatchery apparatus. Observations of the stages of development of both eggs and larvae are described and shown in drawings up to the juvenile stage.

Information on the early development of fishes can make valuable contributions to life history and ecological studies (Balinsky, 1948; Winn and Miller, 1954). This information can also be useful in establishing systematic relationships (Orton, 1953).

This report describes the early development of the hitch, a cyprinid native to California, inhabiting the Pajaro-Salinas, Sacramento-San Joaquin, and Russian River systems, as well as Clear Lake, Lake County. Miller (1945) thought it best to retain the Pajaro-Salinas form, *Lavinia exilicauda harengus,* as a subspecies distinct from *L. e. exilicauda* of the Sacramento-San Joaquin drainage, on the basis of the former's slender body, but stated more specimens of *L. e. exilicauda*—especially from tributaries of San Francisco Bay—are needed to determine the validity of this difference. On the basis of preliminary studies, the hitch of Clear Lake probably represents a third geographic subspecies (John D. Hopkirk, pers. commun.).

Murphy (1948) made extensive observations on the biology of hitch in Clear Lake. He found that, unlike most cyprinids, the hitch must lay its demersal nonadhesive eggs in flowing water. He surmised that eggs hatch in 10 days and become free-swimming larvae in 20 days at 62° F. Kimsey (1960) observed the spawning of Clear Lake hitch in the wave-washed gravel of the lakeshore. Murphy (1948) compiled age and growth tables for the hitch from the juvenile stage onward. But before the present study, there has been no detailed description of the development of the hitch from spawning to the juvenile stage.

METHODS AND MATERIALS

On April 7, 1962, I took spawning fish from Seigler Canyon Creek, and on April 12, 1963, from an unnamed ditch swollen with rainwater near Lakeport. Both sources are Clear Lake tributaries.

I mixed freshly-stripped eggs and milt for 1 minute in a quart jar and then washed them by filling the jar with creek water. After 1 hour I transferred them to a gallon jar, and 6 hours later to a deep enameled dishpan having an air supply. The pan was immersed in a bath of tap

[1] Submitted for publication October 1963.
[2] At present with the Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

water and maintained at 60° to 64° F. for 7 days, until the eggs hatched. Occasionally, methylene blue was added to prevent growth of fungus. On the 24th day, I transferred the prolarvae to an aerated 5-gallon aquarium. Here the temperature fluctuated from 63° to 73° F., paralleling daily air temperatures. The prolarvae were fed finely ground tropical fish food daily.

All observations and drawings were made from live or freshly killed specimens. Specimens were measured against millimeter-graph paper lining the bottom of a petri dish. All measurements are averages from 5 to 10 individuals. I made observations at 15X, 30X, and 45X, and based the drawings on 15X views. I gave the time sequences of development, because I believed that in early stages the temperature range could well have been a natural one. But growth from free-swimming stages onward lagged behind that of wild stock the same age (Murphy, 1948).

The terminology for larval stages follows Hubbs (1943) as defined for cyprinids by Winn and Miller (1954). Stages of development follow Balinsky (1948). The terminology for pigmentation follows Balinsky (1948), as further subdivided by Winn and Miller (1954).

RESULTS

Eggs and Embryos

In 1962 the eggs were subjected to wide temperature fluctuations (61° to 74° F.), and all the prolarvae died within 2 days after hatching.

In 1963 the hitch were raised through the juvenile stage. The eggs were collected from fish spawning in water at 55° F. Transporting them to the laboratory involved a 2.5-hour delay, but the temperature rose to only 61° F. The temperature remained at 61° F. until the eggs reached the dishpan used as an incubator. The time sequence of development is based on this 1963 work.

The freshly stripped eggs appear pale orange. Twenty minutes after fertilization the vitelline membrane lifts and an individual egg appears light yellow (Figure 1A). The fertilized egg's diameter is between 2.00 and 2.25 mm. The diameter of the yolk sphere is 1.25 mm. The eggs are considerably heavier than water and do not adhere to themselves or other objects. No oil globules are visible. Figure 1, B through J, omits the egg shell for clarity and to save space.

A high, rounded blastodisc forms in 1 hour (Figure 1B). In 2 hours the first cleavage appears (Figure 1C). The second cleavage appears at 2.5 hours (Figure 1D). The 8-cell stage can be seen at 3.5 hours. At 5.5 hours, there is a blastoderm with 16 or more cells (Figure 1E). In 12 hours the yolk becomes elongated as the blastoderm begins to migrate around it. At this time the yolks have various oblong shapes, the most common of which is shown (Figure 1F).

The blastopore is closed, and the thickened keel of the embryo can be seen at 35 hours (Figure 1G). The higher, thicker head region can be seen at 39 hours. At 45 hours, there are 4 to 6 somites centered about halfway between the head and tail ends, and the splitting of the internal cavity of the optic cup is visible (Figure 1H). At 54 hours, there are 15 to 17 somites (Figure 1I). At 69 hours, there are 20 to 22 somites; the otic placode is visible; and the tail begins to undulate slowly as it

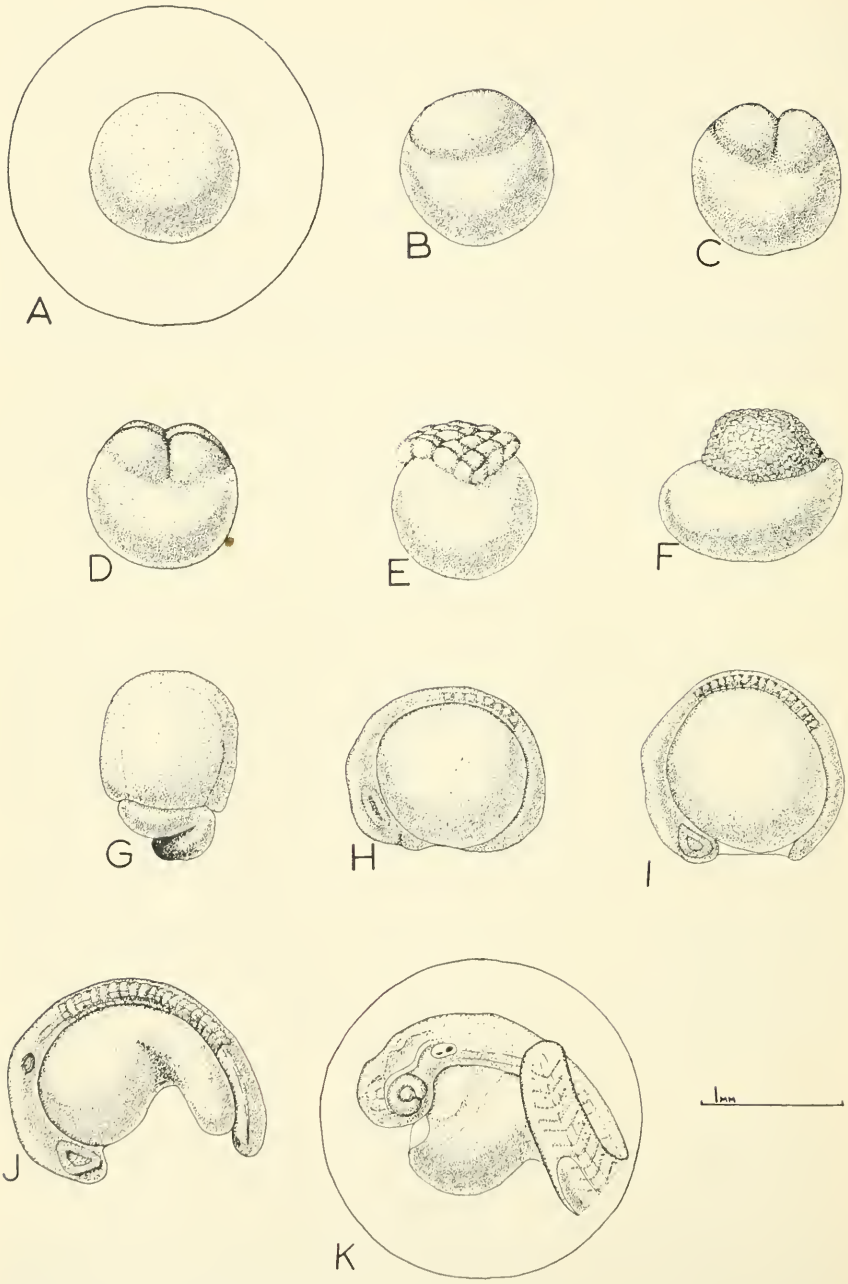

FIGURE 1. Early stages of development of the hitch before hatching: (A) stage 2, 20 minutes; (B) stage 3, 1 hour; (C) stage 4, 2½ hours; (D) stage 5, 3½ hours; (E) between stages 6 and 7, 5½ hours; (F) stage 11, 12 hours; (G) stage 14, 30 hours; (H) stage 18, 45 hours; (I) stage 19, 50 hours; (J) stage 20, 69 hours; (K) stage 22, 108 hours.

frees itself from the yolk, carrying an extension of the yolk sac with it (Figure 1J). At 99 hours the otic capsule, which now his two otoliths, has moved closer to the eye with the straightening of the head region, and the first irregular heart beats can be seen ventral and lateral to the left eye. The beginnings of the vitelline vein appear laterally on the yolk sac at 108 hours, and the embryo is almost constantly undulating (Figure 1K). At 120 hours the heart is a distinct red spot anterior to the yolk sac and ventral to the eye and has a constriction between the auricle and ventricle. There are dorsal, anal, and caudal fin folds. Pigment granules are visible in the eyes, giving them a sooty appearance. On the 6th day the embryo is crowded in the egg membrane and its movements have become vigorous lashings. At 120 hours an embryo is 5 mm long. At 15X it is light grey, with dark grey eyes, and has a light yellow yolk sac. Grossly, embryos appear light yellow with black eyes.

Larvae

Hatching occurs on the 7th day (Figure 2A). The tail breaks through and a few lashes of it free the prolarva, which is 6 mm long. The prolarva lies motionless on its side, unless disturbed. If disturbed, it swims erratically like a tadpole and settles back to the bottom.

The dosal pigment line extends from the interorbital region posteriorly half the length of the body. The posterior cardinal veins and the dorsal aorta appear as two distinct red lines ventral and parallel to the notochord. To the naked eye, the prolarvae appear yellow with two black eyes—the postcardinal veins and the dorsal aorta appearing as a single red line.

Lengths

On the 10th day the prolarvae are 7 mm long. Postlarvae 32 days old are 8.5 mm long, and juveniles 58 days old are 13 mm long.

Eyes and Lateral Line

The eyes are dark grey on the 8th day, becoming black with visible lenses on the 10th. On the 26th day the eyes are iridescent gold with black pupils, the adult condition. On the 22nd day the transparent, filamentous lateral-line organs can be seen at 45X projecting from the sides of the body and the dorsal and lateral sides of the head. These organs are still visible on juveniles 65 days old.

Digestive System Derivatives

On the 10th day the upper and lower jaw bars are visible (Figure 2B). The single-lobed air sac contains air on the 14th day. By the 15th day, gill filament buds are visible on the four gill bars, and the liver is encroaching on the anterior end of the yolk sac. On the 20th day the yolk sac has disappeared, marking the beginning of the postlarval stage. The bright yellow interior of the gut is visible ventral to the anterior end of the air sac on the 27th day. By the 32nd day the gut is constricted about halfway along its length at the future site of the pelvic fins, and the liver now obscures the anterior fourth of the gut. At 46 days the air sac is bilobed, the anterior lobe comprising about one-third the total air sac volume.

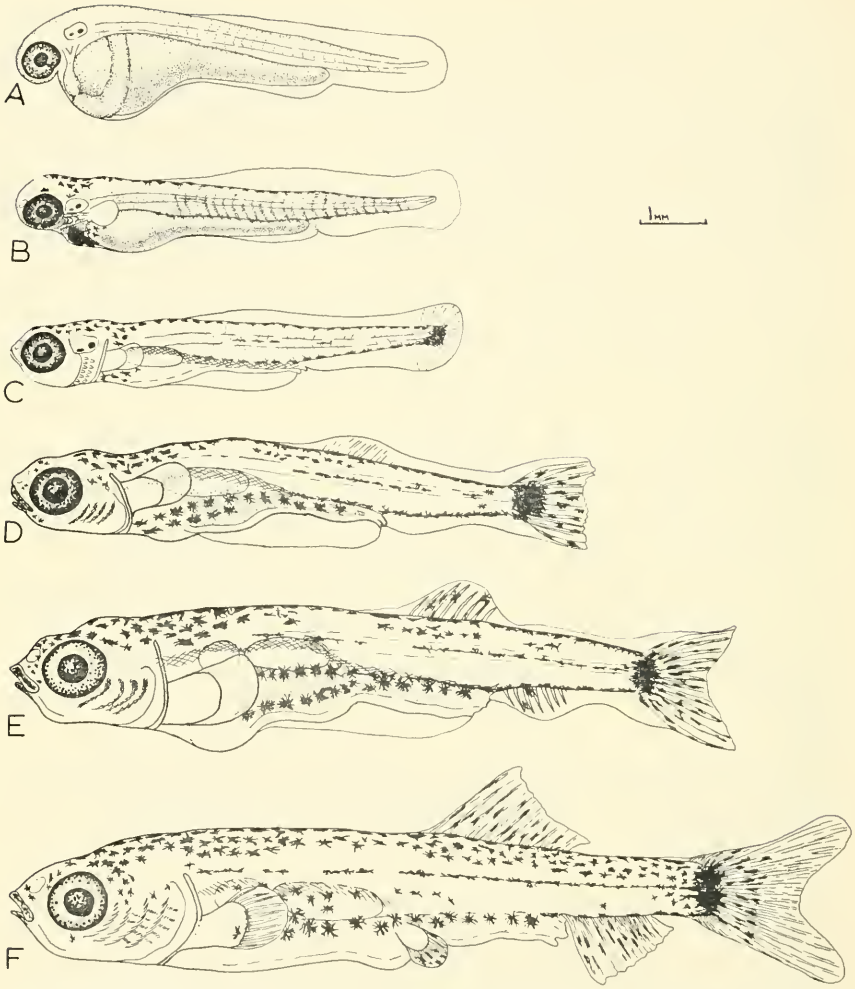

FIGURE 2. Early stages of development of the hitch after hatching: (A) stage 26 (hatching), 7 days; (B) stage 30, 10 days; (C) stage 32, 26 days; (D) stage 35, 36 days; (E) stage 37, 46 days; (F) stage 43, 65 days.

Fins and Activity

On the 10th day, there is some spontaneous swimming, there are slight jaw movements, and the pectoral fins appear as small paddles. By the 14th day the air sac enables the prolarva to swim and rest upright. There are strong breathing and feeding movements of the jaws; and the pectoral fins, now with a definitive muscular lobe, can be moved backward and forward. The vertical, rod-like cleithrum can be seen along the origin of the pectoral fin on the 21st day. By the 36th day, there is an outline of the dorsal fin, and 8 to 10 caudal fin rays are ossified (Figure 2D). By the 46th day 8 to 10 dorsal, 6 to 8 anal, and 16 to 18 caudal fin rays are ossified (Figure 2E). By the 65th day the fins have a full complement of ossified rays (Figure 2F).

Pigmentation

On the 8th day the dorsal and ventral pigment lines extend posteriorly to the caudal peduncle. The ventral aorta and dorsal and lateral sides of the pericardium are pigmented. On the 9th day the dorsal edge of the myotomes has a greenish tinge in contrast to the rest of the embryo. On the 11th day, there are 6 to 8 melanophores along the lateral pigment line. There are 2 to 4 melanophores on each tip of the upper and lower lips by the 26th day and a concentration of melanophores on the ventral aspect of the tail (Figure 2C). All the gill bars are pigmented, the lateral pigment line has 10 to 14 melanophores, and the dorsal and ventral pigment lines are denser by the 29th day. By the 32nd day, there are silvery guanophores on the dorsal lateral aspects of the stomach and intestine, and the pectoral fins have one or two melanophores on each. By the 36th day the concentration of melanophores in the tail region forms a spot covering the base of the caudal fin, and many melanophores have migrated onto the caudal rays. By the 41st day the anal and dorsal fins each have 1 to 4 melanophores. There is a patch of guanophores on the opercles by the 46th day; these cells, along with those of the stomach and intestine, produce the adults' dark-above, light-below appearance. On the 65th day the gill filaments are pigmented. The ventral pigment line never has more than 3 or 4 dispersed melanophores in the trunk region, and no melanophores are seen on the ventral side of the pericardium.

DISCUSSION

The development of the hitch followed the stages of Balinsky (1948) very closely through stage 43. Stages from 44 onward were not seen, because scales were never observed on hitch in the laboratory. Hatching took place at stage 26. The hatching and free-swimming times of 7 and 14 days, respectively, are considerably shorter than Murphy's 1943 estimates. He reported 10 and 20 days, respectively, at similar temperatures.

The large spot at the base of the caudal fin distinguishes young hitch from young carp *(Cyprinus carpio)* and also from young Venus roach *(Hesperoleucus venustus)*, which have only a small spot at the base of the caudal fin (Fry, 1936).

SUMMARY

In the spring of 1962 and 1963, eggs of the Clear Lake hitch were raised under laboratory conditions. The temperature averaged 62° F. The pale yellow, fertilized eggs are 2.25 mm in diameter, and the yolk sphere is 1.25 mm in diameter. There are no oil globules. The eggs are eyed in 5 days and the prolarvae become free-swimming and feed on day 14. They have a full complement of ossified fin rays by day 65. The large caudal spot distinguishes them from the young of most other cyprinids.

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REFERENCES

Balinsky, B. I. 1948. On the development of specific characters in cyprinid fishes. Zool. Soc. London, Proc., 118 (2) : 335-344.

Fry, Donald H., Jr. 1936. Life history of *Hesperoleucus venustus*, Snyder. Calif. Fish and Game, 22 (2) : 65-98.

Hubbs, Carl L. 1943. Terminology of early stages of fishes. Copeia, 1943 (4) : 260.

Kimsey, J. B. 1960. Observations on the spawning of hitch in a lacustrine environment. Calif. Fish and Game, 46 (2) : 211-215.

Miller, Robert R. 1945. The status of *Lavinia ardesiaca*, a cyprinid fish from the Pajaro-Salinas River basin, California. Copeia, 1945 (4) : 197-204.

Murphy, Garth I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish and Game, 34 (3) : 101-110.

Orton, Grace L. 1953. The systematics of vertebrate larvae. Syst. Zool., 2 (2) : 63-75.

Winn, Howard E., and Miller, Robert R. 1954. Native postlarval fishes of the lower Colorado River basin, with a key to their identification. Calif. Fish and Game, 40 (3) : 273-285.

Calif. Fish and Game, 51(2) : 81–112. 1965.

SURVEY OF THE MARINE ENVIRONMENT OFFSHORE OF SAN ELIJO LAGOON, SAN DIEGO COUNTY

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California Department of Fish and Game

During March and April, 1964, California Department of Fish and Game biologist-divers made an ecological investigation of the marine environment offshore of San Elijo Lagoon, San Diego County. This study, conducted for the State Water Quality Control Board, provided estimates of the numbers and diversity of marine life in this area, prior to inception of a community waste discharge through a submarine outfall.

Observations were made along three transects, run perpendicular to the shore, from the intertidal out to depths of 80 feet. Sampling, conducted at 20-foot depth intervals along these lines included; (i) core samples in sand bottom areas, (ii) water temperatures, (iii) visibility estimates, (iv) general bottom description, (v) enumeration (estimates) of plants and animals, (vi) quantitative sampling (by actual removal) of growths on the rocky outcrops within a one-fourth meter square, and (vii) photographs.

The area is composed of two general bottom types: flat sand and rocky shelf. A total of 239 kinds of plants and animals were recorded during the survey; only 16 were from the sand areas. These biological assemblages are potentially threatened by the outfall discharge.

Additional diving surveys are recommended after the outfall begins operation. These post-outfall and pre-outfall data may then be compared to evaluate the adequacy of the existing water quality criteria.

The California Department of Fish and Game and the State Water Quality Control Board (through Regional Board #9—San Diego) entered into an agreement 1 July 1963, whereby Department biologist-divers made an ecological investigation of the marine environment offshore of San Elijo Lagoon, San Diego County. The investigation included but was not necessarily limited to: (i) a general reconnaissance of areas immediately north and south of the Lagoon mouth, and (ii) an intensive examination of the central portion of the study area. The study provided estimates of the numbers and diversity of marine life in the area prior to inception of a community waste discharge through a submarine outfall. Physical data (water temperature and transparency) were recorded each day field work was conducted. Field work was completed 14 April 1964, and the final report submitted to the State Water Quality Control Board on 1 June 1964. The Board reimbursed the Department for expenses incurred during the study.

Because this study compiled information about animal associations common to the area prior to operation of the ocean outfall and employed techniques which may be used by other workers, we feel the data warrants wider distribution than that normally given an interagency report. Without background information of this nature it is almost impossible to evaluate environmental changes occurring after an outfall is in operation.

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AREA DESCRIPTION

San Elijo Lagoon is situated between the communities of Cardiff-by-the-Sea and Solana Beach in northern San Diego County. The study area (Figure 1) lies immediately seaward of the Lagoon mouth. The flat sandy beach in front of the Lagoon is bordered on the north and south by abrupt sandstone cliffs. Currently San Elijo Lagoon does not open to the ocean, being blocked from it by the beach and the roadbed of U.S. Highway 101. The ocean floor slopes gently seaward, reaching an 80-foot depth approximately 5,300 feet offshore. Low sedimentary rock outcrops extend seaward from the bases of the shore-

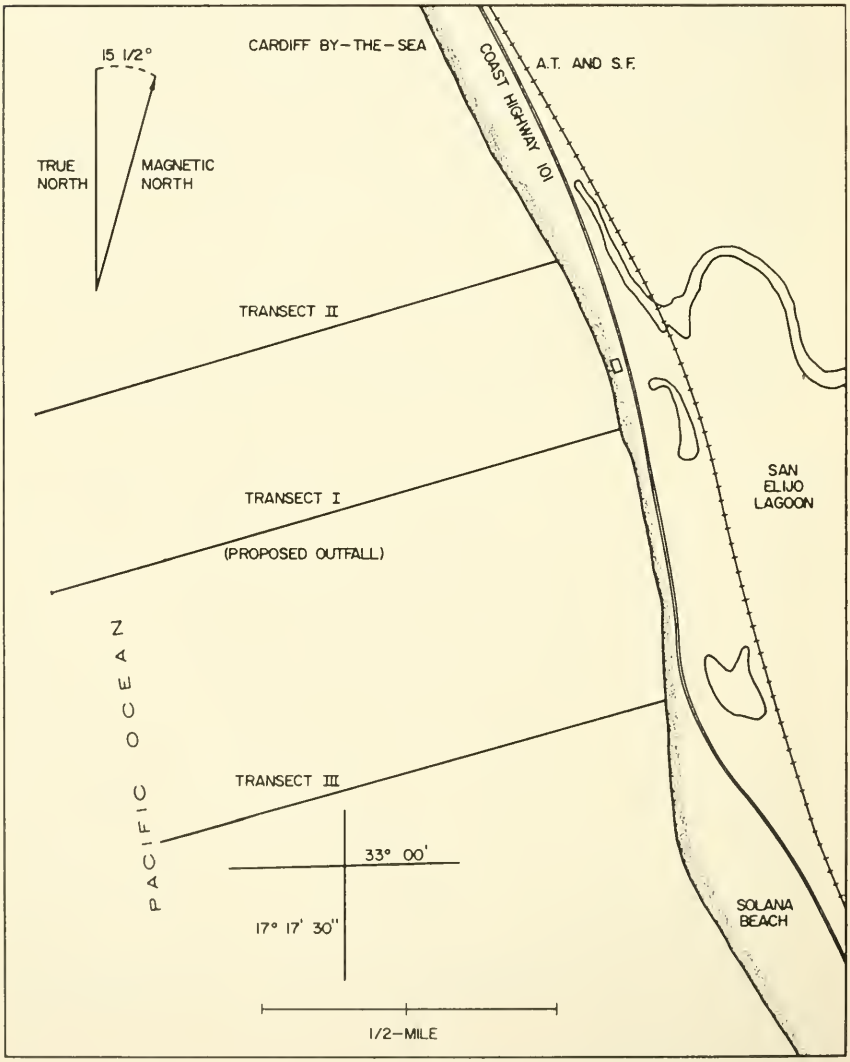

FIGURE 1. Locotion chart and transects surveyed, San Elijo Lagoon area, San Diego County.

side cliffs through the intertidal out to depths of about 60 feet. Beyond this, the bottom is sandy to at least the 80-foot depth (the limit of our study).

Two general bottom assemblages are evident. In the central portion and deeper areas, where the bottom is quite flat and sandy, the fauna is limited in both numbers and kinds of organisms. In the rocky areas on each side of this central portion, which extend several miles north and south of the Lagoon mouth, there are moderate kelp beds and areas of relatively lush epifauna (Figure 2).

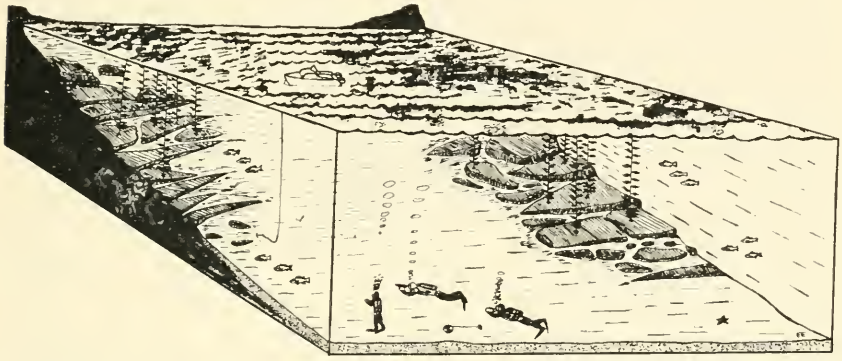

FIGURE 2. Artist's conception of the study area, depicting the northern and southern shelves bounding the central sand area, and the divers conducting a portion of their survey. *Drawing by Earl E. Ebert.*

METHODS

Field work was conducted during March and April 1964. On the first day, a general reconnaissance was conducted from the beach; kelp areas were noted and future transect locations determined. On subsequent field days, three transects were run, perpendicular to shore (approximately 255° magnetic), into 80-foot depths:

Transect I bisects the central sandy area, following the path proposed for the outfall pipe.

Transect II, approximately three-eighths mile north of Transect I, traverses a series of low submerged sandstone—siltstone shelves lying offshore from the sandstone cliffs.

Transect III, approximately one-half mile south of Transect I, traverses the submerged sandstone reefs offshore from the southern cliffs.

Operations were conducted from the Department's 20-foot cabin cruiser *Dolphin* equipped with a Raytheon DE-705A recording fathometer. Bottom contours were continuously recorded along each transect to determine the exact profile (Figure 3).

Observations were made along the transects at each 20-foot depth interval, (Figure 3) commencing in 80 feet and working into the intertidal. Biologist-divers (Figure 4) (2- or 3-man teams) using SCUBA occupied 12 stations on these three transects. Sampling at each station included (with modifications as the situation dictated): (i) a vertical

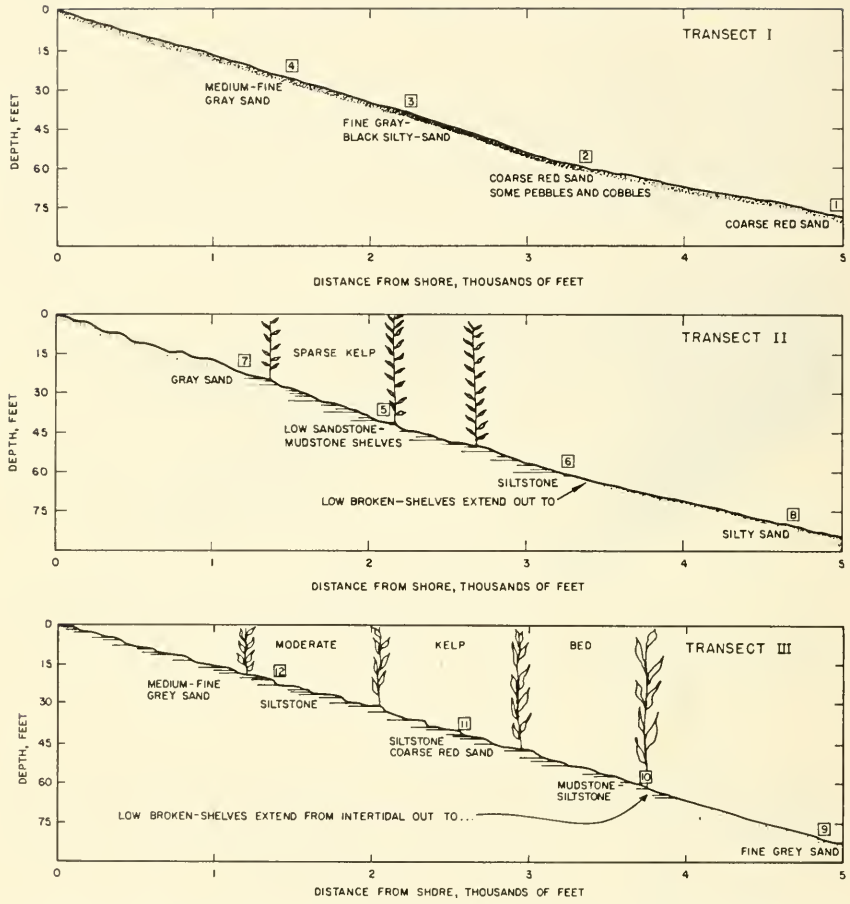

FIGURE 3. Bottom contours interpreted from fathograms. The number within the square indicates the sampling station.

plankton tow (10- or 15-meter depth) using a standard 18 cm diameter, oblong plankton net with 62-micron mesh; (ii) water samples (for salinity determination) at surface and 10-foot depths; (iii) a core sample (on sandy bottom, using a diver-held coring tube); (iv) a bottom sample (scraping along sandy surface for living Foraminifera); (v) taking water temperatures (°C) at bottom and through water column; (vi) making visibility estimates and Secchi disk readings at bottom and through water column; (vii) generally describing the bottom (ripple marks on sand, rocky surfaces on outcrops); (viii) enumerating (estimates) the larger plants and animals (including fish); (ix) quantitative sampling (by actual removal) of growths on rocky outcrops within a one-fourth meter square quadrat; (x) making photographic records of general bottom conditions and of each quadrat prior to sample removal.

The bottom samples were tentatively sorted and preserved during the field operations, with complete analysis being done in the laboratory.

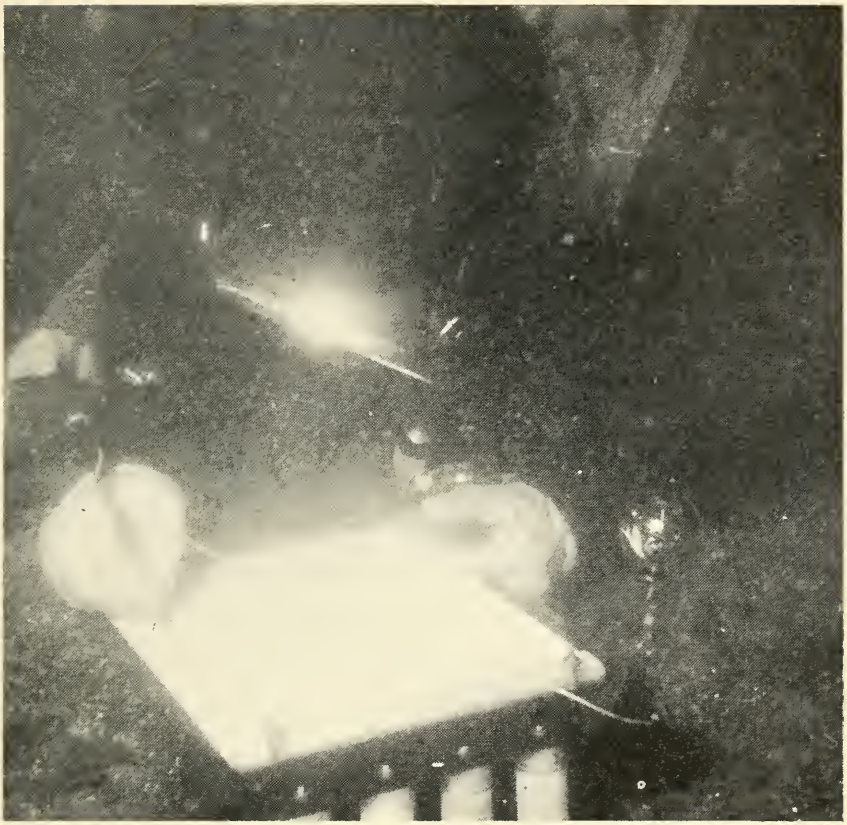

FIGURE 4. Department biologist-diver (Robert R. Given) recording field observations upon a plastic sheet, station 5, transect II. Note the compass and collecting jars attached to the recording board. The diver is holding a specimen in his left hand. Above the left hand is an underwater camera.
Photograph by Charles H. Turner.

All animals and plants collected were recorded. Selected samples of difficult plants and animals (gammarid and caprellid amphipods, decapods, and smaller algaes) were retained for interested specialists.

Although plankton and bottom samples (for Foraminifera) were stained and preserved in the field, the detailed analyses of these and the water samples were not completed in time for inclusion in this report.

On March 25, a low tide permitted us to study and sample the intertidal zones at the base of each transect; these data are included.

GENERAL DISCUSSION OF FINDINGS

The study area may be described as a shallow indentation at the mouth of San Elijo Lagoon, bounded on the north and south by sandstone cliffs and submerged shelves of soft sedimentary rock. Offshore from these shelves the bottom was uniformly covered with gray sand, but between them the hard-packed gray sand bottom grades seaward

through a coarse sand-cobble area into a uniform red sand bottom at 80 feet (Figure 3). Further details of both the physical and biological characteristics of these two main substrate types are included as Appendices 1, 2, and 3.

We use the term "macrofauna" to indicate the more obvious organisms seen on the substrate in cursory observations.

LEVEL BOTTOM AREAS

The macrofaunas characterizing sand and coarse sand-gravel areas are fairly well known and exhibit considerable uniformity in the nearshore areas of the southern California coast.

In the shallows (20 feet, station 4, transect I), the bottom is of hard-packed fine gray sand. A core sample was markedly uniform to at least 8 inches below the water-sand interface. It was taken near the surf zone where there is probably considerable water and sediment movement during most of the year. At the time of our survey there was a heavy surge and the water contained much suspended sediment. Relief (in the form of ripple marks or ridges) was almost non-existent in this region. Common sand dollars and a small unidentified flatfish were the only animals observed.

Further seaward in the central section of the study area (at the 40-foot depth, station 3, transect I) the hard sand grades into a slightly softer, fine gray-black sand. A core sample showed that the bottom was relatively uniform for at least 12 inches, but there was a slight hydrogen sulphide odor at the bottom of the core. Low ripples were present, and there was evidence of worm boring in the troughs. Several small gastropods and a low red alga were recorded.

Coarse red sand forms into high ridges with pebbles and cobbles in the troughs at the 60-foot depth (station 2, transect I). A core sample showed these coarse sediments were overlying a very sticky, gray-black clay-silt which had a slight hydrogen sulphide odor. White sea urchins were present in small numbers, with some large tubeworms, and a boring mollusk.

The 82-foot depth (station 1, transect I) in the central area lies approximately 5,300 feet offshore, and is characterized by about 6 inches of uniform coarse red sand overlying a fine gray sand (Figure 5). The red sand had formed widely-separated ripple marks, with worm holes and castings in the troughs. On the surface there were small white urchins, sand stars and abandoned gastropod shells.

North and south of the central area, seaward of the sandstone shelves, the 80-foot depths are similarly characterized. At the northern edge of the study area (station 8, transect II) 6 inches of soft silty-sand covered at least 8 inches of medium-dark gray sand. Some shelly debris was noticed in the lower dark sands. White sea urchins, sand stars, gastropods, and mantis shrimps were recorded here.

To the south (station 9, transect III), the bottom resembled the northern 80-foot depth area. Ripple marks were present, and the substrate composition down to 10 inches was uniform medium-gray sand with some shelly debris. Small white urchins, sand stars, and small gastropods were seen.

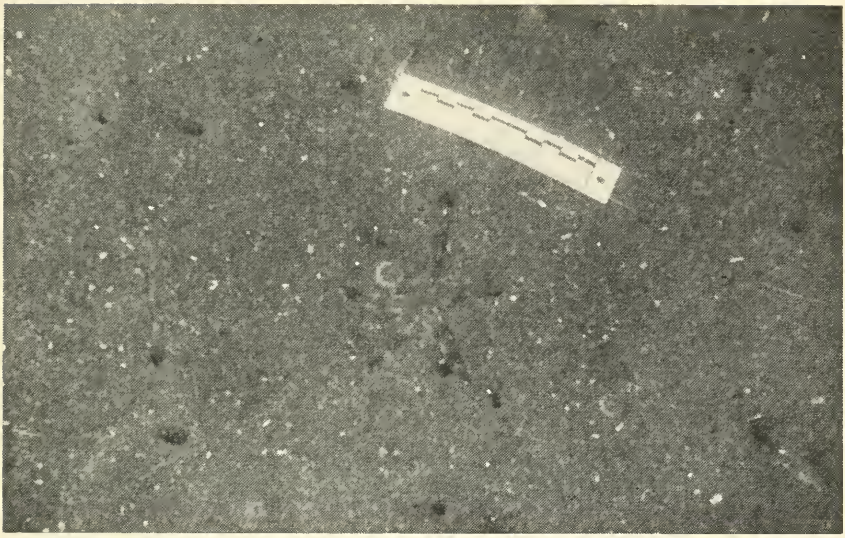

FIGURE 5. Flat bottom sand community typical of deeper portions of the survey area, station 1, transect I, 80 feet. Note the worm holes, starfish and white sea urchins. *Photograph by Charles H. Turner.*

ROCKY BOTTOM AREAS

The biota of the low sandstone and siltstone shelves which extend seaward both north and south of the central study area was so prolific and complex that a detailed study was neeessary to characterize it. The resulting lengthy species lists are presented in various ways in other sections of this report. Because the epifaunal situation here is so complex, generalizations are difficult.

Both shelf areas border the proposed outfall line, and both supported sparse to moderate kelp beds and low-growing algae which, together with bryozoans and sponges, formed thick "mats" over the bare rock (Figure 6). These "mats" provided substrate for a rather lush biological community with innumerable micro-environmental situations.

The only rocky bottom found near the central transect (Station 2A) was approximately 150 yards north of the transect line in 58 feet of water. Fathometer tracings indicated a sudden change in bottom topography, and visual observations showed low siltstone shelves broken by numerous shallow, sanded-in gullies. This area supported a moderately lush epifauna. To retain the continuity of our transect reports, detailed data about this and the intertidal areas are covered as separate sections.

North of the central area, the rocky substrate broke into hard-packed gray sand at the 20-foot depth (station 7, transect II), re-emerging near the 35-foot depths.

At the 38-foot depth (station 5, transect II), low siltstone shelves (12 to 16 inches high with numerous shallow sanded-in channels) supported a sparse kelp bed (with associated fishes) and a thick epifaunal "mat." These soft sedimentary rocks were heavily bored by pholads (Figures 7 and 8).

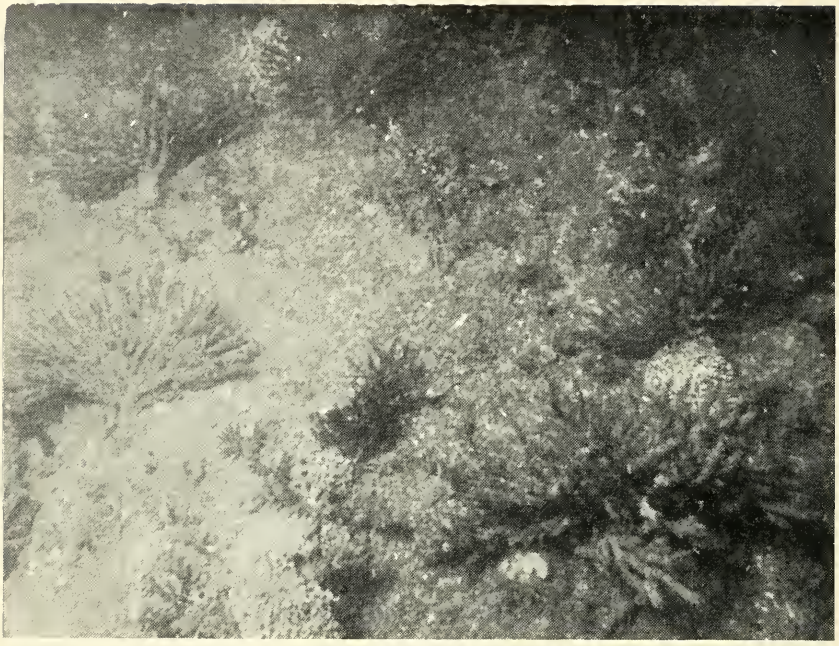

FIGURE 6. Station 5, transect II. Observe the lush epifauna with the predominance of detritus-feeding animal colonies; gorgonians *(Muricea fruticosa* and *M. californica)* and the bryozoan, *Diaperoecia californica. Photograph by Charles H. Turner.*

FIGURE 7. Heavily-bored siltstone shelves at station 5, transect II. Note the purple sea urchins inside the holes in the rock. *Photograph by Charles H. Turner.*

FIGURE 8. The ¼ m^2 quadrat in place at station 5, transect II. Note the similarities between the area inside and outside the quadrat. *Photograph by Charles H. Turner.*

Seaward on line II rocky shelves continued into the 60-foot depths (station 6), broken occasionally by areas of sand. At the 60-foot depth the physical relief of the shelves increased noticeably (up to 3 feet in height) as did the complexity of the associated fauna (Figure 9). Although this station was beyond the outer edge of the kelp bed it retained the characteristic fish fauna associated with these plants (Figures 10 and 11). A survey was made some 200 feet seaward from station 6 into 68 feet of water. Within this distance there was a marked decrease in algae, a further heightening of the rocky relief, and a startling increase in numbers, sizes, and diversity of the fishes. Several of the important sport fish species (sand bass, sculpins, and sheephead) attained large sizes in this rock area. Beyond this depth, the bottom graded into sand (station 8, transect II).

Rocky shelves in the southern section of the study area (transect III) were more clearly defined than those to the north. The physical configuration of the intertidal, (high flat sandstone shelves cut by deep erosion channels, Figure 15) continued through the subtidal out to about 65 feet of water. Some sanding-in was noted at the 15- to 20-foot depths (as in transect II). In the shallows, these rocks seemed to be harder sandstone with less boring and micro-relief than at similar depths on transect II.

At the 20-foot depth (station 12, transect III) the shelves were about 12 inches above the hard sand bottom. The adjacent sand area supported several large surf-grass beds, while on the shelves, giant kelp

FIGURE 9. An area of caves and overhangs near station 6, transect II. Spiny lobsters were in the caves. A sculpin is in the open area facing a lobster's antennae. Note the large red sea urchin in the upper center of the picture and the double siphons of a wart-necked piddock in the lower center. *Photograph by Charles T. Turner.*

and other algae grew profusely. Bottom-dwelling fishes abounded over the sand and shelf areas while the deep undercuts of the shelves at the rock-sand interface housed lobsters and numerous large chamas.

Giant kelp formed a moderately heavy bed from the shallows into the 40-foot depths (station 11, transect III). At this depth, large fissures broke up the flat shelf surface and both the invertebrate and fish faunas were prolific and diverse, particularly around these breaks. The biota on flat areas as much as 40 feet from these fissures was extremely lush and the thick surface "mat" supported a large invertebrate fauna which appeared characteristic of the area (Figure 12).

At 60 feet (station 10, transect III) several changes occurred. The giant kelp had diminished and the shelf configuration had become more broken and rubbly. There were many shallow depressions partially filled with sand, pebbles, and cobbles. The rock surface was heavily bored and there was more micro-relief, indicating a softer rock than was

FIGURE 10. Station 6, transect II. Black-and-yellow rockfish resting in a small ledge on one of the areas' boulders. *Photograph by Charles H. Turner.*

found in the shallower depths. The sponge-algae-bryozoan "mat" supported a large invertebrate population.

Seaward of this rubble area the shelves deteriorated completely and at a depth of 80 feet the bottom was sandy (station 9, transect III).

EXTRALIMITAL SAMPLING

We deviated from our three transects in order to establish the extent of the low sandstone reefs in the northern part of the study area and to investigate the intertidal area. To maintain continuity in our written report of the transect surveys, extralimital station data are presented separately.

Station 2A

Station 2A, approximately 150 yards north of transect line 1, in 58 feet of water, was examined on March 9. Several observations and collections were made here: (i) a 15-meter vertical plankton tow; (ii) a bottom sample for Foraminifera analysis; (iii) bottom temperature (13.1°C); (iv) bottom visibility (5 feet); (v) a general visual survey

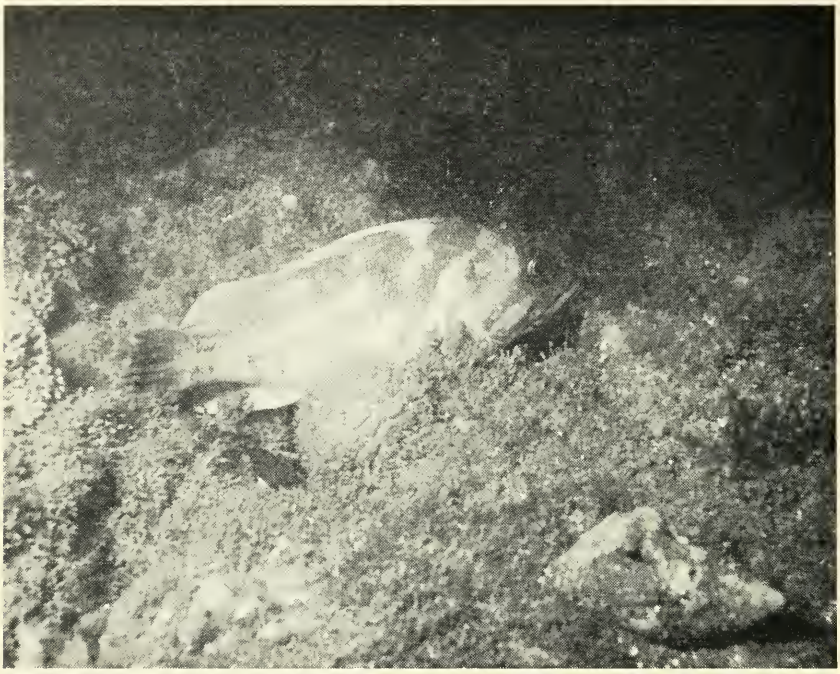

FIGURE 11. A whitebelly rockfish resting alongside an orange sponge near station 6, transect II. Note the low but lush epifauna covering the rock. *Photograph by Charles H. Turner.*

FIGURE 12. A kelp rockfish on a portion of the rocky outcrop at station 11, transect III. Note the lush epifauna encrusting the rock shelf. *Photograph by Earl E. Ebert.*

of area; and (vi) a quantitative bottom sample (one-half meter square).

The bottom consisted of low siltstone shelves emerging 1 to 14 inches above the surrounding red sand. These were interspaced with shallow gullies partially filled with 1 to 4 inches of the red sand. The siltstone was heavily bored by pholads and generally covered by a bryozoan-sponge-algae "mat." Some large bryozoan "heads" (*Diaperoccia californica*), scattered gorgonians, and low-growing red and brown algae formed relief up to 10 inches above the shelf surface. Sixty-nine different animals and plants were recorded (Table 1).

The Intertidal Area

Three intertidal stations were occupied on March 25 during low tide (—0.8 feet). The more obvious floral and faunal assemblages (Table 2) were noted along the measured transect lines (Figure 13), and a quantitative substrate sample (one-fourth meter square) was removed.

The intertidal area offshore of San Elijo Lagoon combines sand- and rock-bottom communities. North and south of the central area, beach cliffs extend discontinuously into the sea and form raised shelf areas interspaced with sand. Centrally (transect I) the area is hard-packed gray sand without visible animals or plants.

TABLE 1

Plants and Animals Recorded at Station 2A off San Elijo Lagoon, San Diego County March 9, 1964

Scientific name	Abundance in the study area (ca 100 sq ft)	Remarks
ALGAE		
Cystoseira osmundacea	(P) *	Up to 10 inches high
Callophyllis violacea	(C) †	Crisp, delicate
Corallina officinalis	(A) ‡	Dominant coralline algae
Bossiella orbigniana	(C) §	
Bossea sp.	(P)	
Rhodymenia pacifica	(P)	
INVERTEBRATES and ASCIDIANS		
Protozoa		
Gromia oviformis	(C)	In holes and crevices
Porifera		
Haliclona cinerea	(P)	One piece 6-by-6-inches
Ficulina suberea lata	(P)	One small piece
Dercitus syrmatitus	(P)	
Lissodendoryx noxiosa	(A)	Amorphous; among bryozoan branches
Cnidaria		
Muricea californica	1 per 2 sq. meter	Up to 8 inches high
Muricea fruticosa	1 per 2 sq. meter	Up to 10 inches high
Astrangia lajollaensis	(P)	Two 1-by-3-inch patches of corallites
Epiactis prolifera	(2)	
Sertularella sp.	(S) **	Hydrotheca without annulations
Sertularella sp.	(S)	Hydrotheca with annulations
Aglaophenia pluma	(C)	On the ascidian *Styela montereyensis*

TABLE 1—Continued

Plants and Animals Recorded at Station 2A off San Elijo Lagoon, San Diego County March 9, 1964

Scientific name	Abundance in the study area (ca 100 sq ft)	Remarks
INVERTEBRATES and ASCIDIANS—Continued		
Annelida		
Serpula vermicularis	(4)	In calcareous tubes
Halosydna brevisetosa	(C)	Easily broken up, exact count difficult
polynoid—unidentified	(1)	All elytra missing
Syllidae	(P)	
Terebellidae	(P)	
Phyllochaetopterus prolifica	(P)	Several tubes
Arthropoda		
Balanus concavus pacificus	(P)	Several small isolated individuals
Cirolana harfordi	(2)	
Alpheus bellimanus	(1)	
Pugettia dalli	(1)	Juvenile male
Lophopanopeus heathii	(1)	
Gammaridea	(C)	
Pontonia californiensis	(2)	Male and female commensal within the gut area of the ascidian *Ascidia vermiformis*
Sipunculoidea		
Dendrostomum pyroides	(2)	In holes in rock
Mollusca		
Conus californicus	(4)	Juveniles
Crepipatella lingulata	(1)	
Calliostoma supragranosum	(2)	
Cerithiopsis carpenteri	(1)	
Amphissa versicolor	(1)	
Mitrella carinata	(P)	
Dendrodoris albopunctata	(P)	
Callistochiton palmulatus	(1)	
Chama pellucida	(2)	3 mm long
Kellia laperousii	(4)	All small
Hiatella arctica	(2)	All small
Parapholas californica	(6)	Up to 4 inches long
Ostrea lurida	(3)	Up to 5 inches long
Lithophaga subula	(P)	Boring in the rocks
Bryozoa		
Diaperoecia californica	(C)	Scattered small "heads"
Cellaria mandibulata	(P)	
Crisia sp.	(P)	
Crisia operculata	(C)	
Costazia robertsoniae	(C)	Encrusting on coralline algae and hydroid stems
Tubulipora admiranda	(P)	Small patches
Holoporella brunnea	(P)	One patch
cheilostome (unidentified)	(P)	One small patch
cyclostome (unidentified)	(P)	One small patch

TABLE 1—Continued

Plants and Animals Recorded at Station 2A off San Elijo Lagoon, San Diego County March 9, 1964

Scientific name	Abundance in the study area (ca 100 sq ft)	Remarks
INVERTEBRATES and ASCIDIANS—Continued		
Echinodermata		
Ophiothrix spiculata	(3)	In crevices
Amphipholis sp.	(1)	Mutilated
Lytechinus anamesus	10/sq. meter	
Henricia leviuscula	(C)	2 color phases observed
Pisaster giganteus	(2)	
Eupentacta quinquesemita	(C)	In crevices and on top of rocks
Ascidiacea		
Chelyosoma productum	(1)	On rock
Styela montereyensis	(2)	10 inches long, heavily encrusted with algae and hydroids.
Sigillinaria aequali-siphonis	(C)	In crevices and holes
Cystodytes lobatus	(P)	Large lobe-shaped colonies
Ascidia vermiformis	(1)	Under rock; containing a pair of commensal shrimp
VERTEBRATA		
Alloclinus holderi	(2)	Small reef-dwelling species; hides in crevices and among the low-growing algae
Rathbunella sp.	(2)	
Zalophus californianus	(1)	California sea lion; apparently "side walk" superintending" the biologists at work

* P Present but relative abundance not estimated.
** S Sparse—widely scattered throughout area but nowhere numerous.
† C Common—unevenly present throughout the area and only occasionally numerous.
‡ A Abundant—numerous and evenly distributed throughout the area.
§ Parentheses around the symbol for abundance indicate occurrence within the quadrat; a ½ meter square.

TABLE 2

Obvious Intertidal Organisms Observed During the Survey Offshore of San Elijo Lagoon, San Diego County

Transect II	Transect III
Anthopleura xanthogrammica	*Acanthina spirata*
Colpomenia sinuosa	*Anthopleura elegantissima*
Corallina officinalis	*Anthopleura xanthogrammica*
Dictyopteris zonarioides	*Balanus tintinnabulum*
Egregia laevigata	*Colpomenia sinuosa*
Phyllospadix torreyi	*Corallina officinalis*
Prototheca staminea	*Mitella polymera*
Ulva sp.	*Mytilus californianus*
	Olivella biplicata
	Ostrea lurida
	Phyllospadix torreyi

The northern (transect II) intertidal shelves are low-lying, 1 to 6 inches high (Figure 14) and support moderate animal and plant communities, vulnerable to burial by sand. Only 5 algae and 3 animals were recorded within the quadrat (Table 3). By contrast, the southern (transect III) intertidal shelves are 3 to 4 feet high, and support a richer and more complex community (Figure 15). Four algae and 10 animals were noted within the quadrat for this area (Table 3).

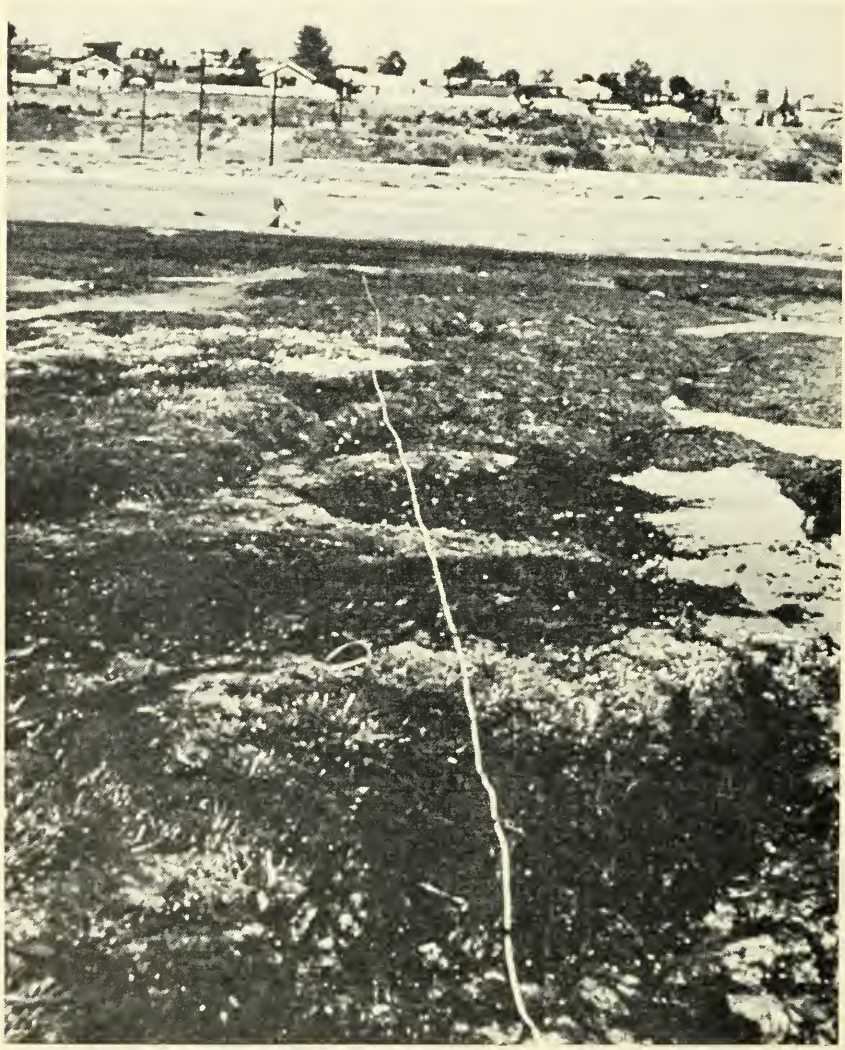

FIGURE 13. Our metered transect line laid across the intertidal shelves of transect II. *Photograph by Robert R. Given.*

FIGURE 14. The intertidal area of transect II. Note the low shelf profiles compared with those of transect III (Figure 15). *Photograph by Robert R. Given.*

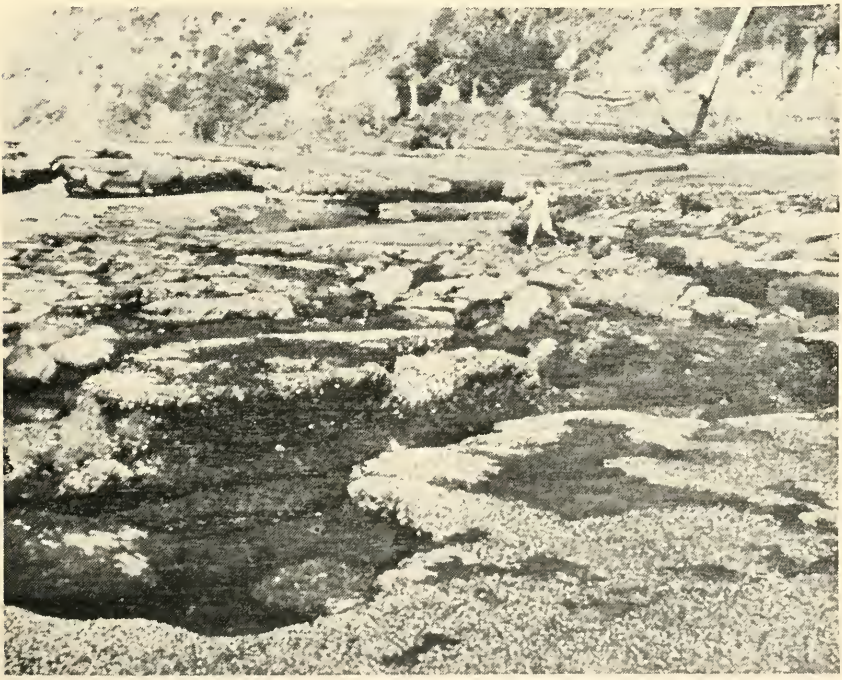

FIGURE 15. The intertidal area of transect III; typified by large shelves and deep erosion channels. *Photograph by Robert R. Given.*

SUMMARY OF FINDINGS

The area offshore from San Elijo Lagoon, San Diego County, is composed of two general bottom types: flat sand and rocky shelf. During our survey in this area, we recorded 239 kinds of plants and animals (Appendix 4). Sixteen of these were from flat sand bottom areas, all the rest were associated with the various rock areas.

There were sparse to moderately heavy beds of giant kelp in 15 to 60 feet of water both north and south of the Lagoon mouth. The northern kelp beds were sparse and less extensive than the southern, disappearing at the 50-foot depths (2,800 feet from shore) although suitable substrate extended into 70-foot depths. Within these rock shelf-kelp bed areas there were lush and varied animal and plant assemblages.

The predominant animal life consisted mainly of gorgonians, bryozoans, sponges, purple sea urchins, red sea urchins and large wavy top-snails. The sea urchins and snails were feeding upon giant kelp.

TABLE 3

Rocky Intertidal Plants and Animals Recorded from off San Elijo Lagoon, San Diego County, March 25, 1964

(from one-quarter meter square quadrat)

Transect II

ALGAE

Ulva sp. "sea lettuce", common throughout the quadrat
Zonaria farlowii—scattered small plants; 1–1½ inches high
Corallina officinalis—common
Corallina vancouverensis—common
Bossiella orbigniana—sparse

INVERTEBRATES

Annelida
Serpulidae—2
Cirratulidae—1

Mollusca
Olivella biplicata—14

Transect III

ALGAE

Ulva sp.
Gelidium purpurascens—most common alga in the quadrat
Corallina officinalis—sparse
Corallina vancouverensis—sparse

INVERTEBRATES

Cnidaria
Anthopleura elegantissima—3

Annelida
Serpulidae—common on *Mytilus californianus* valves

Arthropoda
Cirolana harfordi—2

Mollusca
Mytilus californianus—11 specimens (7 less than 1¼ inches long)
Chama pellucida—3 (1-inch in diameter)
Nuttallina californica—2 (½ and ¾ inches long)
Epitonium sp.—7
Turbonilla kelseyi—1 (½-inch long)
Acmaea pelta—2

Bryozoa
Membranipora tuberculata—common on stems of *Gelidium purpurascens*

We anticipate an increase in the sea urchin population and a decrease in kelp density once the outfall becomes operative. Apparently the urchins can tolerate effluent-rich areas while the kelp is adversely affected. Urchin-favored environments are apparent near the White Point outfall (Palos Verdes Peninsula) and in areas near the Point Loma outfall.

On April 14, our last field day, temperatures ranged from 11.5°C at 80 feet to 15.4°C at the surface and water clarity was reduced to zero by a heavy plankton (dinoflagellate) bloom. Over 90 percent of the organisms in the sampled water were *Ceratium* sp.; the remainder were *Noctiluca* sp. and *Gonyaulax* sp. These dinoflagellates caused the ocean to assume a rusty-brown color. During earlier surveys, water temperatures had ranged from 12.6°C (80 foot depth) to 14.7°C at the surface and water visibilities varied from 9 to 30 feet (Figure 16).

An ocean outfall in this area poses a potential threat to the lush biological assemblages. However, strict water quality criteria for discharged effluent will reduce this potential threat. To evaluate and

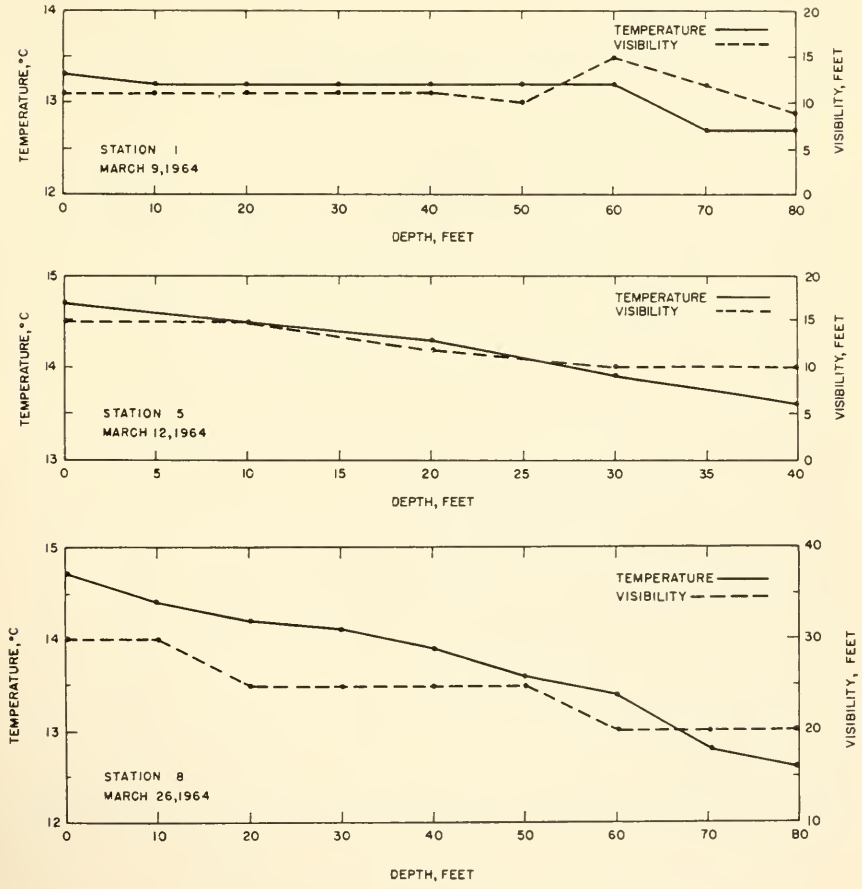

FIGURE 16. Temperature-visibility curves as functions of depth.

record changes in the environment, diving surveys (at least semi-annually) should be conducted to enumerate the animals and plants present. These post-outfall data may then be compared with our pre-outfall information and any changes that occur can be evaluated and the adequacy of existing water quality criteria judged. Being a renewable, but not a replaceable resource, the marine environment should not be destroyed. A healthy marine environment attracts bathers, sightseers, fishermen, and others seeking recreation and pursuing hobbies. Clean, healthy coastal waters and sewage disposal are not incompatible if water quality criteria are established at a protective (safe for all) level.

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REFERENCES

Abbott, R. Tucker. 1954. American seashells. New York, D. Van Nostrand Co., 541 p.

Dawson, E. Yale, Michael Neushul, and Robert D. Wildman. 1960. Seaweeds associated with kelp beds along southern California and northwestern Mexico. Pacific Naturalist, 1 (14) : 80 p.

Durham, J. Wyatt, and J. Laurens Barnard. 1952. Stony corals of the eastern Pacific collected by the *Velero III* and *Velero IV*. Allan Hancock Pacific Expeditions, 16 (1) :110 p.

Fitch, John E. 1953. Common marine bivalves of California. Calif. Fish and Game, Fish Bull. 90, 102 p.

Fraser, C. McLean. 1937. Hydroids of the Pacific coast of Canada and the United States. Toronto Univ. Press, 207 p.

Hartman, Olga. 1961. Polychaetous annelids from California. Allan Hancock Pacific Expeditions, 25, 226 p.

Laubenfels, M. W. de. 1932. The marine and fresh water sponges of California. Proc. United States Nat. Mus., 81 (4) :140 p.

Light, S. F. 1957. Intertidal invertebrates of the central California coast. S. F. Lights "Laboratory and field text in invertebrate zoology." revised by Ralph I. Smith and others. Berkeley Univ. Calif. Press, 446 p.

Marine Advisers, Inc. 1963a. Bottom investigation along route of proposed Cardiff-Solana Beach outfall. prepared for: County of San Diego. March, 1963.

—1963b. Oceanographic investigation for proposed Cardiff-Solana Beach sewage outfall. prepared for: Special District Services, County of San Diego.

Osburn, Raymond C. 1953. Bryozoa of the Pacific coast of America. Allan Hancock Pacific Expeditions, 14, 841 p.

Roedel, Phil M. 1953. Common ocean fishes of the California coast. Calif. Fish and Game, Fish Bull. 91, 184 p.

Schmitt, Waldo L. 1921. Marine decapod Crustacea of California. Univ. Calif., Publ. Zool., 23, 470 p.

Turner, Charles H., Earl E. Ebert, and Robert R. Given. 1964. An ecological survey of a marine environment prior to installation of a submarine outfall. Calif. Fish and Game. 50 (3) :176-188.

APPENDIX 1

Physical Data for 12 Stations Occupied During a Survey of the Marine Environment Offshore from San Elijo Lagoon, San Diego County, March-April 1964

Station number	Date	Depth (feet)	Bottom temp. °C	Visibility (feet) Secchi disk	Visibility (feet) diver estimate	Bottom description
1	3-9-64	82	12.7	9	5	Core 7 inches long; top 6 inches of coarse red sand, bottom inch breaks sharply to fine gray sand. Ripple marks 6 inches high with 30 inches between crests. Ripple slopes roughly aligned in a north-south direction. Worm tubes and debris common in the troughs.
2	3-9-64	60	13.1	–	5	Core 7 inches long; top 3½ inches of loose, coarse red sand with some cobbles and pebbles; then a sharp break occurs to very sticky, gray-black clayey silt, with a slight H_2S odor. Many large cobbles and pebbles (cobbles to 4 by 8 inches). Ripple marks 6 to 8 inches high with 30 inches between crests. Ripple slopes roughly aligned in a north-south direction.
3	3-9-64	40	13.4	–	1	Core 12 inches long of uniform fine grayish-black micaceous, silty sand, with a slight H_2S odor. Ripple marks ¼ to ½ inches high with 3 inches between crests. Ripple slopes roughly aligned in a north-south direction.
4	3-9-64	20	13.8	–	2	Core 8 inches long of uniform medium-fine micaceous gray sand. Ripple marks ¼ to ½ inches high with 3 inches between the crests. Ripple slopes roughly aligned in a north-south direction.
5	3-12-64	38	13.6	11	10	Sandstone-mudstone shelves to 16 inches high; pavement-like on top with erosive cuts filled with sand, gravel and cobbles. Area appears subjected to severe scouring and moderate sanding-in. Heavily bored by pholads.

APPENDIX 1—Continued

Station number	Date	Depth (feet)	Bottom temp. °C	Visibility Secchi disk	(feet) diver estimate	Bottom description
6	3-12-64	60	13.4	–	5	Broken siltstone shelves to 3 feet high; scattered boulders partially sanded in 4 to 6 inches by coarse red sand.
7	3-12-64	20	–	–	3	Hard-pack gray sand bottom. Much sand in suspension to 6 inches off the bottom, oscillating due to wave action. Ripple marks ¼ to ½ inches deep, their slopes paralleling the shoreline.
8	3-26-64	80	12.6	38	20	Core 12 inches long; top 6 inches of soft, light colored, silty sand, remaining portion of medium grain sand, dark gray, with some shelly debris. Ripple marks ¼ to ½ inches high with 3 to 4 inches between the crests. We observed no detrital build up in the shallow troughs. The ripple slopes roughly aligned in a north-south direction.
9	3-26-64	80	12.6	38	20	Core 10 inches long of uniform medium-fine micaceous gray sand, shelly debris present at the bottom. Ripple marks similar to Station 8.
10	3-26-64	60	–	–	25	Low broken mudstone-siltstone shelves; crevices and depressions containing coarse red sand. Rocks, from cobbles to boulders (1-foot in diameter), liberally distributed over the area. Extensive pholad boring.
11	3-26-64	40	–	–	25	Siltstone shelves extending 4 to 5 feet up from the coarse red sand. Shelves with extensive crevices and prominent ledges, some as deep as 5 or 6 feet. Moderate pholad boring.
12	3-27-64	20	–	–	15	Low broken siltstone shelves extending out from the intertidal. Shelves to one foot high, undercut except on inshore sides. Sand adjacent to shelves is hard packed medium-fine light gray sand with some shelly debris on its surface. Suspended bottom sediments oscillated with the wave action. Ripple marks were ½ to ¾ inches high with 3 inches between the crests. The slopes roughly align in a north-south direction.

APPENDIX 2

Biological Station Data (Excluding Fishes) Recorded During a Survey of the Marine Environment Offshore from San Elijo Lagoon, San Diego County, March–April 1964 (300 square feet surveyed at each station)

Organisms	Transect I				Transect II				Transect III			
	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta. 7	Sta. 8	Sta. 9	Sta. 10	Sta. 11	Sta. 12
ALGAE												
Chlorophyta												
Cladophora graminea											(S) §	
Phaeophyta												
Cystoseira osmundacea					P *	S **				A ‡		P
Egregia laevigata					P	S						
Eisenia arborea					S	I				C †	C	
Laminaria farlowii					C					S to C	C	S to C
Macrocystis pyrifera												P
Pachydictyon coriaceum												
Rhodophyta												
Agardhiella coulteri			S									
Bossiella orbigniana					S	(C)				P(C)		
Callophyllis violacea					S							
Corallina officinalis					S(S)					A(A)	A(S)	C
Laurencia subopposita												P
Lithothamnion sp.					P							
Lithothrix aspergillum											(A)	
Plocamium pacificum												C
Rhodymenia sp.											P	
Flowering Plants												
Phyllospadix torreyi												C
INVERTEBRATES AND ASCIDIANS												
Protozoa												
Folliculina sp.					(P)					C		
Gromia oviformis					(C)	(P)				(P)	(P)	
Porifera—sponges												
Axinella sp.					C						C	
Dysidea amblia					P							
Ficulina suberea lata						(C)						
Haliclona cinerea										(P)		
Haliclona sp.					(P)	(C)					C	
Hymenamphiastra cyanocrypta											C	
Myxilla agennes						(C)						
Parcsperella psila											(P)	

APPENDIX 2—Continued

Organisms	Transect I				Transect II				Transect III			
	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta. 7	Sta. 8	Sta. 9	Sta. 10	Sta. 11	Sta. 12
Porifera—sponges—continued												
Plocamia igzo					P							
Rhabdodermella nuttingi						(S)						
Tethya aurantia						A				6–7	P	
Tetilla arb										1		
Porifera—unid.—red										(P)		
Porifera—unid.—orange						(A)				(C)	A	
Cnidaria												
Hydrozoa—hydroids												
Aglaophenia pluma					C					C		
Diplocheilus allmani											(C)	
Plumularia setacea						(P)						
Plumularia sp.						P (A)						
Sertularella sp.					(P)							
hydroids—unid						(S)						
Anthozoa—anemones, etc.												
Anthopleura xanthogrammica					1/M²	P						
Astrangia lajollaensis					P	A				P		
Corynactis californica						A (10)					P	
Edwardsiella sp.				6/½M²								
Lophogorgia chilensis						6						
Muricea californica					1/M²	4/M²					C	
Muricea fruticosa					3/M²	6/M²				C	C	
Pachycerianthus sp.					4	S						
Paracyathus stearnsi						C					C	
Ceriantheridae—unid										P		
Tealia sp.					P					P		
Scyphozoa												
Pelagia panopyra								2				
Nemertina—nemertean worms										(2)		
Nematoda—nematode worms						(A)						
Annelida—annelid worms												
Chaetopteridae												
Chaetopterus variopedatus					P (1)	5				(1)		
Phyllochaetopterus prolifica						(3)				2–3		
Telepsavus costarum										(1)		
Cirratulidae					(2)							
Dorvilleidae										(1)		

| | | |

APPENDIX 2—Continued

Organisms	Transect I				Transect II				Transect III			
	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta 7	Sta. 8	Sta. 9	Sta. 10	Sta. 11	Sta. 12
Arthropoda—crabs, shrimp, etc.—cont.												
Crustacea—continued												
Pontonia californiensis					2	4						
Pugettia dalli					(1)					(3)		
Pugettia richii											(2)	
Pugettia sp.										(1)		
grapsoid crab—unid.										(1)		
hermit crab—unid.					(2)					(6)		
masking crab—unid.						(1)						
pinnixid crab—unid.										(1)		
Mollusca												
Amphineura—chitons												
Callistochiton crassicostatus					(3)							
Callistochiton palmulatus										(1)		
Ischnochiton regularis					(1)							
Gastropoda—snails												
Acteocina culitella											(1)	
Acteon punctocoelata			P									
Anisodoris nobilis						(1)						
Archidoris montereyensis						1						
Astraea undosa					4/M[2]					1/3M[2]		
Burchia redondoensis					1	2				10		
Cadlina limbaughi										2		
Caecum californicum											(9)	
Caecum dalli											(2)	
Calliostoma gloriosum						(1)						
Calliostoma supragranosum					(1)	(4)					(1)	
Chacea ovoidea					S	S						
Conus californicus					3/M[2]	1				C (1)	S (6)	
Crepidula excavata											(2)	
Crepipatella lingulata					(2)	(2)				(1)	(P)	
Cypraea spadicea											10	
Dendrodoris albopuncta					15 (2)	P				C		
Flabellina iodinea					1						2	
Glossodoris californiensis					1	P						
Glossodoris porterae											1	
Kelletia kelletii					7/M[2]	20		1		3/M[2]	C	
Marginella sp.					(2)							

| | | |

APPENDIX 2—Continued

Organisms	Transect I				Transect II				Transect III			
	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6	Sta. 7	Sta. 8	Sta. 9	Sta. 10	Sta. 11	Sta. 12
Echinodermata												
Ophiuroidea—brittle stars												
Amphipholis sp.										(2)	(1)	
Ophioplocus esmarki					4							
Ophiopteris papillosa					(1)						(1)	
Ophiothrix spiculata					C(3)	C(8)					P(6)	
Asteroidea—sea stars												
Astrometis sertulifera					P(1)							
Astropecten armatus	1/10M²					P		8	1			
Henricia leviuscula										P	2	
Luidia foliolata	1/5M²											
Pisaster giganteus					10	3					C	
Pisaster ochraceus					2							
Holothuroidea—cucumbers												
Eupentacta quinquesemita										(2)		
Parastichopus parvimensis						1					C	
holothurians—unid.										(2)		
Echinoidea												
Dendraster excentricus	1/10M²				20/M²							
Lytechinus anamesus	1/M²					P		20/M²	30/M²			
Strongylocentrotus franciscanus					2/M²	100+					C	
Strongylocentrotus purpuratus					4/M²						10	
urchin—unid.										1		
Ascidiacea												
Ascidia vermiformis					2	2						
Cystodytes lobatus										C		
Pycnoclavella stanleyi					P							
Sigillinaria aequali—siphonis					C(10-15)					P	A	A
Styela montereyensis					3/M²	C				C		
Tridemnum opacum										(C)		

* P = Present but relative abundance not estimated.
** S = Sparse—widely scattered throughout the area but nowhere numerous.
† C = Common—unevenly present throughout the area and only occasionally numerous.
‡ A = Abundant—numerous and evenly distributed throughout the area.
§ = Parentheses around the symbol for abundance indicates occurrences within the quadrat; a $\frac{1}{4}$ meter square.

APPENDIX 3

Relative Abundance of Fishes Recorded Offshore from San Elijo Lagoon, March-April, 1964

Common Name	Transect II				Transect III			
	Sta. #5 No. (size in inches)	Sta. #6 No. (size in inches)	Sta. #7 No. (size in inches)	Sta #8 No. (size in inches)	Sta. #9 No. (size in inches)	Sta. #10 No. (size in inches)	Sta. #11 No. (size in inches)	Sta. #12 No (size in inches)
shovelnose guitarfish								2 (18–20)
California halibut								1 (14)
diamond turbot						1 (10)		
flatfish (unid.)*								
kelp bass	4 (4–14)	20 (8–16)					100 (6–22)	25 (12–13)
sand bass		50 (16–26)					5 (14–22)	
ocean whitefish		1 (14)						
halfmoon							15 (8–10)	
opaleye								P†
kelp perch	5 (3–4)							
black perch		5 (10)					75 (5–9)	5
rubberlip perch		1 (14)					15 (10–14)	
pile perch							50 (5–7)	10
blacksmith		30 (4–8)					100 (3–8)	
garibaldi							5 (8–10)	P
señorita	75 (5–8)					75 (5–8)	50 (6–8)	P
California sheephead		15 (16–20)					25 (10–36)	1 (large female)
bluespot goby		2 (3)				20/10M[2]	20 (4–5)	
sculpin		25 (8–16)					10 (8–11)	
kelp rockfish		3 (9–12)					50 (8–14)	
black-and-yellow rockfish		2 (12)						
treefish							2 (12–14)	
whitebelly rockfish		1 (12)						
painted greenling								P
wooly sculpin	10 (2–5)							
cabezon						1 (12)		
island kelpfish‡								

* = observed only at Station 4.
† P = present but not enumerated.
‡ = observed only at Station 2A.

APPENDIX 4

Plants and Animals Observed Offshore from San Elijo Lagoon, San Diego County, March and April 1964

Scientific Name	Common Name
ALGAE	
Agardhiella coulteri (Harvey) Setchell	red alga
Bossea sp.	coralline alga
Bossiella orbigniana (Decaisne) Silva	coralline alga
Callophyllis violacea J. Agardh	red alga
Cladophora graminea Collins	green alga
Corallina officinalis (Harvey) Kützing	coralline alga
Corallina vancouverensis Yendo	coralline alga
Cystoseira osmundacea (Menzies) C. Agardh	brown alga
Egregia laevigata Setchell	feather boa
Eisenia arborea Areschoug	southern sea palm
Gelidium purpurascens Gardner	red alga
Laminaria farlowii Setchell	ribbon kelp
Laurencia subopposita (J. Agardh) Setchell	red alga
Lithothamnion sp.	coralline alga
Lithothrix aspergillum J. E. Gray	coralline alga
Macrocystis pyrifera (Linnaeus) C. A. Agardh	giant kelp
Pachydictyon coriaceum (Holmes) Okamura	brown alga
**Phyllospadix torreyi* S. Watson	surf grass
Plocamium pacificum Kylin	red alga
Rhodymenia pacifica Kylin	red alga
Rhodymenia sp.	red alga
Ulva sp.	sea lettuce
Zonaria farlowii Setchell and Gardner	brown alga
INVERTEBRATES AND ASCIDIANS	
Acmaea pelta Eschsholtz	limpet
Acteocina culitella Gould	snail
Acteon punctocoelata (Carpenter)	barrel snail
Aglaophenia pluma (Linnaeus)	hydroid
Alpheus bellimanus (Lockington)	pistol shrimp
Alpheus dentipes Guérin	pistol shrimp
Alpheus sp.	pistol shrimp
Amphipholis sp.	brittle star
Amphissa versicolor Dall	snail
Anisodoris nobilis MacFarland	dorid nudibranch
Anthopleura elegantissima (Brandt)	aggregate anemone
Anthopleura xanthogrammica (Brandt)	solitary anemone
Archidoris montereyensis (Cooper)	dorid nudibranch
Ascidia vermiformis (Ritter)	solitary ascidian
Astraea undosa Wood	wavy top-snail
Astrangia lajollaensis Durham	aggregate coral
Astrometis sertulifera (Xantus)	sea star
Astropecten armatus Gray	sand star
Axinella sp.	orange sponge
Balanus concavus pacificus Pilsbry	acorn barnacle
Balanus trigonus Darwin	acorn barnacle
Barentsia discreta Busk	entoproct
Bugula neritina (Linnaeus)	bryozoan
Burchia redondoensis Burch	tower snail
Cadlina limbaughi Lance	dorid nudibranch
Caecum californicum Dall	snail
Caecum dalli Bartsch	snail
Calliostoma gloriosum Dall	trochid snail
Calliostoma supragranosum Carpenter	trochid snail
Callistochiton crassicostatus Pilsbry	chiton
Callistochiton palmulatus Carpenter	chiton
Cancer anthonyi Rathbun	cancer crab
Cancer sp.	cancer crab
Caprellidea	caprellid amphipods
Cellaria mandibulata Hincks	bryozoan
Ceriantheridae	tube anemones
Cerithiopsis carpenteri Bartsch	snail
Chacea ovoidea Gould	wart-necked piddock
Chaetopterus variopedatus (Renier)	parchment tube worm
Chama pellucida Sowerby	agate chama
Chelyosoma productum Stimpson	solitary ascidian
Chlamys rubida (Hinds)	pecten
Cilicaea cordata Richardson	isopod
Cirolana harfordi (Lockington)	isopod
Cirratulidae	polychaete worm (family)
Conus californicus Hinds	cone snail
Corynactis californica Carlgren	aggregate anemone
Costazia robertsoniae (Canu and Bassler)	bryozoan

Crepidula excavata Broderlip — slipper snail
Crepipetella lingulata Gould — half-slipper snail
Crisia maxima Robertson — bryozoan
Crisia operculata Robertson — bryozoan
Crisia sp. — bryozoan
Cypraea spadicea Gray — chestnut cowry
Cystodytes lobatus Ritter — compound ascidian
Dendraster excentricus Eschsoltz — sand dollar
Dendrodoris albopunctata (Cooper) — dorid nudibranch
Dendrostomum pyroides Chamberlin — sipunculid worm
Dercitus syrmatitus de Laubenfels — sponge
Diaperoecia californica d'Orbigny — bryozoan
Diopatra ornata Moore — onuphid polychaete worm
Diplocheilus allmani Torrey — hydroid
Dorvilleidae — polychaete worm (family)
Dysidea amblia de Laubenfels — sponge
Edwardsiella sp. — sand anemone
Epiactis prolifera Verrill — prolific anemone
Epitonium sp. — wentletrap snail
Eudistylia polymorpha Johnson — feather duster worm
Eupentacta quinquesemita (Selenka) — sea cucumber
Euphrosinidae — polychaete worm (family)
Ficulina suberea lata Johnson — sponge
Filicrisia franciscana (Robertson) — bryozoan
Flabelligeridae — polychaete worm (family)
Flabellina iodinea (Cooper) — aeolid nudibranch
Folliculina sp. — ciliate protozoan (attached)
Gammaridea — gammarid amphipods
Glossodoris californiensis (Bergh) — dorid nudibranch
Glossodoris porterae (Cockerell) — dorid nudibranch
Gromia oviformis Dujardin — testate protozoan
Haliclona cinerea (Grant) — purple sponge
Haliclona sp. — sponge
Halosydna brevisetosa Kinberg — scale worm
Hemisquilla stylifera (Milne-Edwards) — mantis shrimp
Henricia leviuscula (Stimpson) — sea star
Hiatella arctica (Linnaeus) — rough nestling clam
Hinnites multirugosus (Gale) — rock scallop
Holoporella brunnea (Hincks) — encrusting bryozoan
Hymenamphiastra cyanocrypta de Laubenfels — blue encrusting sponge
Ischnochiton regularis (Carpenter) — chiton
Kelletia kelleti Forbes — whelk snail
Kellia laperousii Deshayes — nestling clam
Lacospira sp. — serpulid polychaete worm
Leptopecten latiaurata (Conrad) — kelp scallop
Lima hemphilli Hertlein and Strong — file shell
Lissodendoryx noxiosa de Laubenfels — sponge
Lithophaga subula (Reeve) — date mussel
Lophogorgia chilensis (Verrill) — pink gorgonian
Lophopanopeus heathii Rathbun — crab
Loxorhynchus grandis Stimpson — spider crab
Luidia foliolata Grube — sea star
Lyonsia californica Conrad — bivalve mollusk
Lyrula hippocrepis (Hincks) — bryozoan
Lytechinus anamesus Clark — white sea urchin
Maldanidae — polychaete worm (family)
Marginella sp. — marginella snail
Megathura crenulata Sowerby — keyhole limpet
Membranipora tuberculata (Bose) — bryozoan
Mitra catalinae Dall — miter snail
Mitra idae Melville — miter snail
Mitrella carinata (Hinds) — keeled snail
Muricea californica Aurivillius — gorgonian
Muricea fruticosa Verrill — gorgonian
Mytilus californianus Conrad — mussel
Myxicola infundibulum (Renier) — sabellid polychaete worm
Myxilla agennes de Laubenfels — sponge
Nassarius mendicus Gould — whelk snail
Navanax inermis (Cooper) — tectibranch mollusk
Nematoda — nematode worms (phylum)
Nemertina — nemertean worm (phylum)
Nereidae — polychaete worm (family)
Nuttallina californica (Reeve) — chiton
Ocenebra circumtexta Stearns — triton snail
Olivella biplicata Sowerby — olive snail
Ophioplocus esmarki Lyman — brittle star
Ophiopteris papillosa (Lyman) — brittle star
Ophiothrix spiculata LeConte — brittle star
Ostrea lurida Carpenter — native oyster
Pachycerianthus sp. — tube anemone
Pachycheles holosericus Schmitt — crab
Pachycheles pubescens Holmes — crab
Paguristes ulreyi Schmitt — hermit crab
Panulirus interruptus (Randall) — spiny lobster
Paracyathus stearnsi Verrill — solitary coral
Paresperella psila de Laubenfels — sponge
Parapholas californica Conrad — scale-sided piddock
Parastichopus parvimensis Clark — sea cucumber
Pelagia panopyra (Peron and Lesueur) — purple jellyfish
Penitella penita (Conrad) — flap-tipped piddock
Petrolisthes sp. — crab
Phidolopora pacifica Robertson — lacy bryozoan
pholad — piddock
Phoronis sp. — phoronid worm
Phyllochaetopterus prolifica Potts — chaetopterid polychaete worm

Scientific Name	Common Name	Scientific Name	Common Name
Invertebrates and Ascidians—Continued			
Phyllodocidae	polychaete worm (family)	*Sertularella* sp.	hydroid
Pisaster giganteus (Stimpson)	sea star	*Serpulorbis squamigerus* (Carpenter)	tube-building snail
Pisaster ochraceus (Brandt)	sea star	*Sigillinaria aequali-siphonis* (Ritter & Forsyth)	social ascidian
Plocamia igzo de Laubenfels	sponge	*Spirorbis* sp.	serpulid polychaete worm
Plumularia setacea (Ellis)	hydroid	*Strongylocentrotus franciscanus* (Agassiz)	red sea urchin
Plumularia sp.	hydroid	*Strongylocentrotus purpuratus* (Stimpson)	purple sea urchin
Polinices recluzianus Deshayes	moon snail	*Stycla montereyensis* (Dall)	solitary ascidian
Polynoidae	scale-worm polychaete (family)	Syllidae	polychaete worm (family)
Pontonia californiensis Rathbun	shrimp	*Synnotum aegypticum* (Audouin)	bryozoan
Protothaca stamimea (Conrad)	clam	Tanaidacea	tanaid crustacean (order)
Pugettia dalli Rathbun	crab	*Tealia* sp.	large red sea anemone
Pugettia richii Dana	crab	*Telepsavus costarum* Clarapéde	chaetopterid polychaete worm
Pugettia sp.	crab	Terebellidae	polychaete worm (family)
Pycnoclavella stanleyi Berrill and Abbott	social ascidian	*Terebra pedroana* Dall	auger snail
Rhabdodermella nuttingi Urban	calcareous sponge	*Tethya aurantia* Pallas	orange sponge
Sabellaria cementarium Moore	sand-tube polychaete worm	*Tetilla arb* de Laubenfels	sponge
Sabellariidae	polychaete worm (family)	*Thalamoporella californica* (Levinsen)	bryozoan
Scrupocellaria diegensis Robertson	bryozoan	*Trididemnum opacum* (Ritter)	colonial ascidian
Scrupocellaria sp.	bryozoan	*Trivia solandri* Sowerby	trivia snail
Salmacina tribranchiata (Moore)	serpulid polychaete worm	*Trophonopsis lasius* Dall	trophon snail
Serpula vermicularis Linnaeus	serpulid polychaete worm	*Tubulipora admiranda* Osburn	bryozoan
Serpulidae	polychaete worm (family)	*Turbonilla kelseyi* Dall and Bartsch	turbonille snail
VERTEBRATES			
Alloclinus holderi (Lauderbach)	island kelpfish	*Paralichthys californicus* (Ayres)	California halibut
Brachyistius frenatus Gill	kelp perch	*Pimelometopon pulchrum* (Ayres)	California sheephead
Caulolatilus princeps (Jenyns)	ocean whitefish	Pleuronectiformes	flatfish
Chromis punctipinnis (Cooper)	blacksmith	*Rathbunella* sp.	ronquil
Clinocottus analis (Girard)	wooly sculpin	*Rhacochilus toxotes* Agassiz	rubberlip perch
Coryphopterus nicholsi (Bean)	bluespot goby	*Rhacochilus vacca* (Girard)	pile perch
Embiotoca jacksoni Agassiz	black perch	*Rhinobatos productus* (Ayres)	shovelnose guitarfish
Girella nigricans (Ayres)	opaleye	*Scorpaena guttata* Girard	sculpin
Hypsopsetta guttulata (Girard)	diamond turbot	*Scorpaenichthys marmoratus* (Ayres)	cabezon
Hypspops rubicunda (Girard)	garibaldi	*Sebastodes atrovirens* (Jordan and Gilbert)	kelp rockfish
Medialuna californiensis (Steindachner)	halfmoon	*Sebastodes chrysomelas* (Jordan and Gilbert)	black-and-yellow rockfish
Oxyjulis californica Gunther	señorita	*Sebastodes serriceps* (Jordan and Gilbert)	treefish
Oxylebius pictus Gill	painted greenling	*Sebastodes vexillaris* (Jordan and Gilbert)	whitebelly rockfish
Paralabrax clathratus (Girard)	kelp bass	*Zalophus californianus* (Lesson)	California sea lion
Paralabrax nebulifer (Girard)	sand bass		

* Flowering plant.

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DEVELOPMENTAL TEMPERATURE TOLERANCE AND RATES OF FOUR SOUTHERN CALIFORNIA FISHES, *FUNDULUS PARVIPINNIS, ATHERINOPS AFFINIS, LEURESTHES TENUIS,* AND *HYPSOBLENNIUS SP.*[1]

CLARK HUBBS

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Eggs of four fishes, California killifish, *Fundulus parvipinnis* Girard; topsmelt, *Atherinops affinis* (Ayres); California grunion, *Leuresthes tenuis* (Ayres); and mussel blenny, *Hypsoblennius* sp., were incubated at a variety of temperatures. Larvae hatched at temperatures between 16.6 and 28.5, 12.8(–) and 26.8, 14.8 and 26.8, and 12.0(–) and 26.8(+)°C respectively. The minimum temperature for successful incubation can be correlated with breeding season. California killifish eggs hatch more slowly in total darkness while light seems to kill California grunion eggs.

Although the inshore fish fauna of southern California is well known, little information is available concerning the effects of temperature on the development of many common species. Because survival of the early stages of a species often limits the population, knowledge of the critical factors affecting these stages is significant to understanding each species.

These studies were carried out on four common inshore fishes. Similar studies have been conducted on three other local species, Pacific sardine, *Sardinops caeruleus* (Girard), northern anchovy, *Engraulis mordax* Girard (Lasker, 1964), and wooly sculpin, *Clinocottus analis* (Girard) (Hubbs, in press). All of these species have eggs with wide temperature tolerances, and developmental rates which double with less than a 10°C increase at low temperatures, and less thermal differences at high temperature. Three of the four species in this report, California killifish, topsmelt, and mussel blenny follow the same pattern. The exception, California grunion, is less responsive to temperature change, probably a result of its tide-controlled reproductive habits.

The thermal limits correspond to the reproductive seasons in southern California; summer breeders having warm-tolerant eggs and winter breeders cold-tolerant eggs.

ACKNOWLEDGMENTS

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MATERIALS AND METHODS

The gametes were removed from the fish following the techniques of Strawn and Hubbs (1956). Except for the mussel blenny eggs, which were laid and fertilized in an aquarium held at 16°C, the eggs were taken from fishes in tanks held at 16 and 17°C. After fertilization the eggs were placed in 200 mm glass preparation dishes, plastic capped test tubes, or plastic boxes divided into 43x49x50 mm chambers, each filled with 40 mm of water. Isolated eggs in the test tubes were placed in a temperature gradient block (Lasker, 1964, and Hubbs, in press). Temperature variations in the block during these experiments were less than ±0.3°C. The eggs in the glass preparation dishes were placed on aquarium shelves where temperatures varied up to ±1.0°C, and in prolonged experiments rose as the season progressed. The eggs were checked daily and developmental stages recorded. With few exceptions the larvae were not fed. The parental stocks used in these experiments were collected in the vicinity of La Jolla, California.

California killifish were collected from the northwest corner of Mission Bay and the Torrey Pines Lagoon. Since no consistent differences in thermal responses were noted for fertilized eggs from the two different localities or the two reciprocal intraspecific hybrids, the results are plotted together. Some of the Torrey Pines Lagoon eggs were reared in sea water, others in fresh water (aged San Diego tapwater). Development was parallel through hatching. The only significant difference was that the larvae died quicker in the preparation dishes with fresh water than in those with sea water. Although a ripe killifish female was found March 28 most were not mature until April 24. Eggs of California killifish have short adhesive threads that can attach together but the eggs are readily teased apart and placed in the appropriate experimental chambers.

The grunion were collected on the beach at Scripps Institution of Oceanography. Many ripe females were observed on March 27 while only a few were found earlier, on March 13. In other years they have been obtained as early as February and peak runs are recorded from late March through May (Walker, 1952). Grunion eggs are nonadhesive and lack filaments, making them easy to manipulate in experiments.

The topsmelt stocks were collected in Torrey Pines Lagoon and along the beach south of Scripps Institution of Oceanography. Despite the different catch localities, the thermal responses were similar for each group. Adult topsmelt are difficult to maintain in the laboratory and routine examination for ripeness often killed the females. Ripe females were not available until mid-May; however, ripening eggs were noted in females from both catch localities in February. Mature topsmelt eggs have long filaments which must be cut to isolate the eggs for temperature gradient block experiments.

The blenny eggs were obtained from the side of a glass aquarium where they had been spawned naturally. The tank contained two females and a male. The nest, guarded by the male, was situated behind a rock. The eggs were first noted by Carol Bumgardner on May 2 and two developmental stages were observed. Since many had already cleaved when introduced into the experimental chambers, the timing of these tests is less precise than in the others.

Many additional eggs were removed May 6. The nest area was covered with eggs again on May 7. These eggs were again removed and the area was covered on May 8. Another aquarium of blennies contained an egg mass in a mollusk shell in February. These *Hypsoblennius,* obtained near Scripps Institution of Oceanography, are similar to *H. jenkinsi* of the Gulf of California.

California killifish, *Fundulus parvipinnis*

Fertilized California killifish eggs gastrulate at temperatures between 12.9 and 37.7°C (Table 1 and Figure 1). However, successful development to hatching occurs over a narrower range, 16.6 to 28.5°C. Testing at the extreme temperatures resulted in infrequent and abnormal gastrulations or early death.

The development time increased rapidly as the temperature dropped, doubling with 4°C cooling below 21°C. Above 21°C the development time shortens by 5/6 with a 4°C increase in temperature.

TABLE 1

Average times (in days) required for *Fundulus parvipinnis* eggs and larvae to form circulation, hatch, and die of starvation if not fed. The eggs and larvae were maintained in 200 mm glass preparation dishes set in a lighted aquarium room.

°C	Circulation formed	Hatched	Died
37.7	x		
37.5	x		
37.5	x		
37.2	x		
37.0	x		
36.5	x		
34.0	2.0		
33.7	2.0		
33.4	2.0		
32.6	2.0		
32.5	2.0		
31.5	2.0		
28.5	2.0	14.0	16.0
28.2	3.0	died	
23.7	4.0	18.8	27.8
22.9	4.0	18.0	25.0
22.7	4.0	17.6	24.3*
22.6	4.0	20.7	29.6
22.5	4.0	18.2	25.0*
22.4	4.0	died	
22.3	4.0	24.0	?
21.8	5.0	29.2	38.1**
21.5	5.0	21.2	31.4
21.4	4.0	21.9	32.0
21.3	?	21.4	27.4
21.2	?	20.3	27.0*
21.2	?	20.7	30.5
21.2	?	22.0	30.9
17.2	12.0	45.5	46.5

* Reared in fresh water.
** 70 fertilized eggs in preparation dish—no other held more than 20.

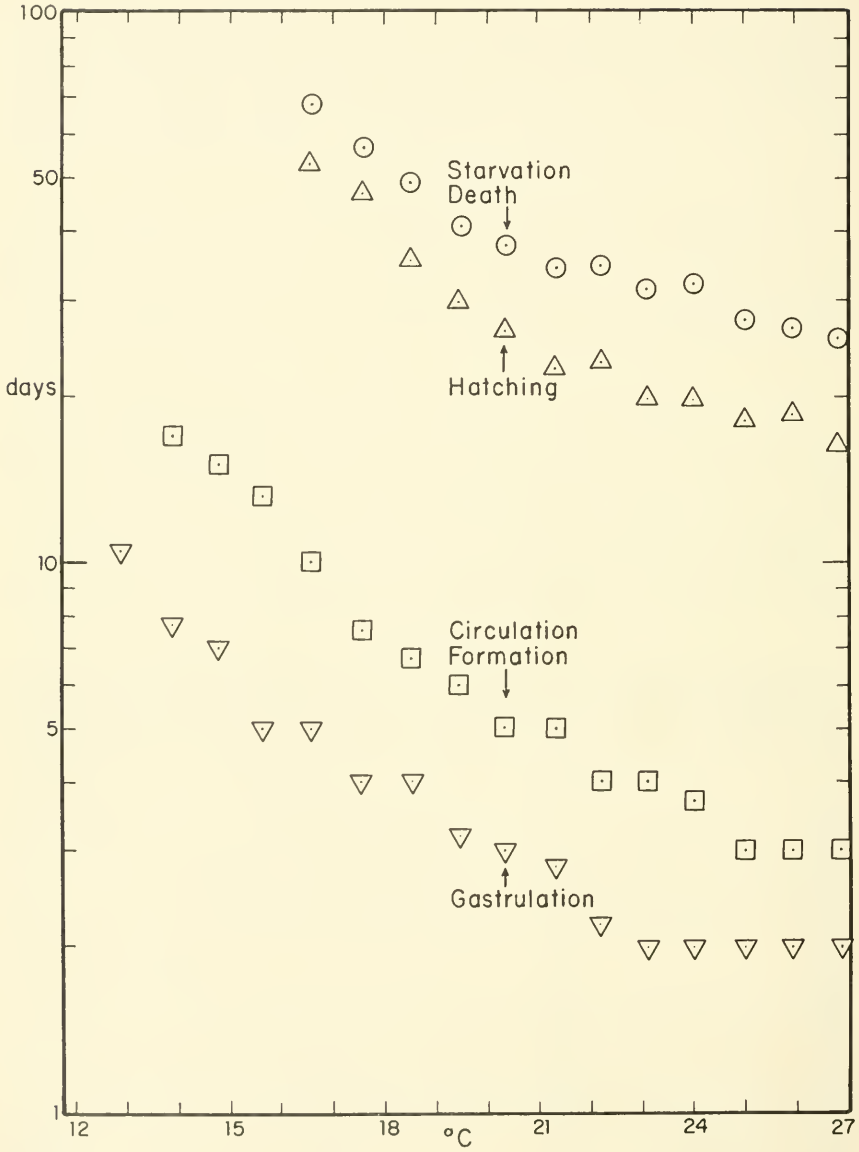

FIGURE 1. Average effects of temperature on development rates of California killifish eggs exposed within 15 minutes of stripping.

The preparation dish and test tube experiment results were similar except that hatching and death occurred quicker in the dishes. This may be due to either the greater amount of thermal fluctuation or the greater amount of light in the preparation dishes. Development may speed up more during the warm interval than it is slowed during the cold periods. However, the more rapid hatching is apparent in preparation dish experiments held above 21°C, temperatures at which thermal

effects on developmental rates are minimal. Moreover, the hatching times often equal those of eggs held at a constant temperature 2°C or more above that of the ±1.0°C conditions of the preparation dishes. Therefore it is likely that light is the significant factor. The eggs held in the constant temperature block test tubes were kept in darkness except for the daily checking period, an exposure to light of less than 1 minute. The eggs in the preparation dishes were in a well-lighted aquarium room.

Eggs in the three preparation dish experiments using fresh water hatched faster and died sooner than comparable experiments in sea water. Otherwise the results were similar. No difference was noted under similar circumstances in the test tube experiment.

In one experiment where the eggs were crowded, hatching was delayed, but these survived much longer without feeding than those in comparable experiments. Undoubtedly crowding slowed the developmental processes.

The experiment listed at 17.2°C was held sufficiently long for seasonal warming to occur. This was the only one in which the temperature variations exceeded ±1.0°C. At the start of the experiment the temperatures were about 15.5°C and at the end, 6 weeks later, 19.0°C. The temperature rose gradually over the 6 weeks, and weekly variations never exceeded ±0.8°C.

California grunion, *Leuresthes tenuis*

Fertilized grunion eggs gastrulated at temperatures between 12 and 32.5°C; however, hatching occurred only between 14.8 and 26.8°C (Figure 2). Eggs in the two warmer experiments, at 29.8 and 32.5°C became abnormal early in their development and did not hatch. At 32.5°C the eggs gastrulated but did not begin organ formation, while at 29.8°C the eggs progressed through circulatory formation but cephalization was abnormal. The snouts were so foreshortened that the eyes fused together. The high frequency of abnormality, *ca* ½, in the 25.9 and 26.8°C test tube eggs indicate this is near their thermal maximum.

The temperature does not seem to effect the developmental rate of grunion as much as it does killifish. Except for hatching, an increase of about 9°C is required to double the rate at any given stage. The steeper slope of the hatching time is difficult to explain. Walker (1952) has shown that the eggs hatch in response to agitation and the experimental containers were agitated daily. Walker also showed that agitation would occur about 10 to 14 days after naturally laid eggs were fertilized. Therefore those held at temperatures above 19°C would be able to hatch if agitated as they would be on the next series of high tides. Those at colder temperatures would not be ready but might hatch during the second high tide series a month after fertilization if they had not already been washed out to sea. The significance of 19°C seems to be substantiated by the apparent break in developmental rates at that temperature separating steeper slopes (colder) from leveler slopes (warmer).

Two other factors, light and crowding, seem to affect hatching and survival. A series of eggs were placed in plastic boxes with 1, 2, 4, 8, 16, or 32 eggs in each chamber. At about 23°C hatching percentages were notably lower if more than two eggs were in each chamber

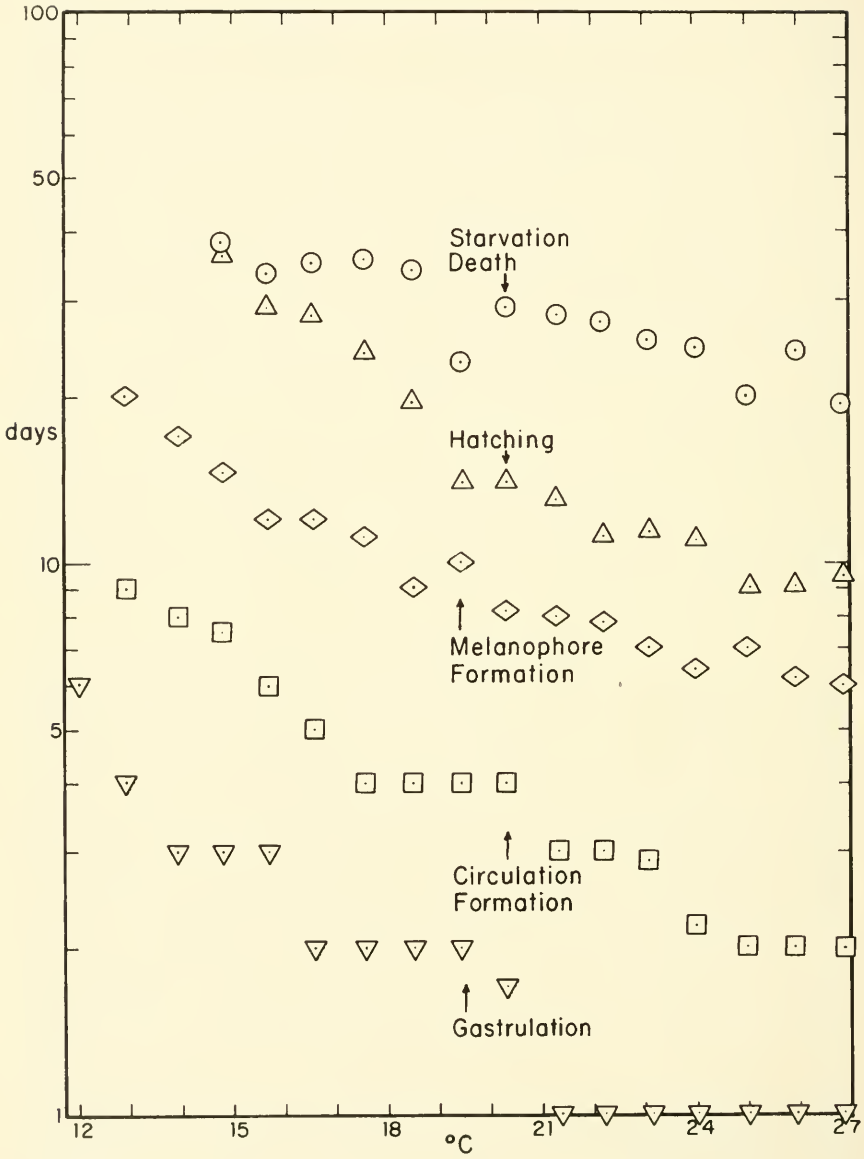

FIGURE 2. Average effects of temperature on development rates of California grunion eggs exposed within 15 minutes of stripping.

(Table 2). Moreover, there was also a delay in average hatching time. At about 18°C a similar reduction in hatching percentage occurred, but only when more than eight eggs were in each chamber. Hatching was not delayed even in the 32 egg chambers. These hatching times approximate those in the test tube experiments.

None of the above preparation dish experiments had hatching percentages approaching those in the test tubes (90 percent). The other

TABLE 2

Effects of crowding on eggs of *Leuresthes tenuis* at 23 and 18°C. The chambers were 43 x 49 x 40 mm deep.

Number of eggs per chamber	23°C Pct. hatch	23°C Average days to hatch	18°C Pct. hatch	18°C Average days to hatch
1	44	10.5	50	20.5
2	39	10.9	33	25.5
4	19	11.6	62	22.5
8	4	11.3	46	21.0
16	1	11.0	34	22.3
32	2	11.8	19	22.7

important variable is the amount of light available to the preparation dishes. In nature these eggs would be laid under about 4 inches of sand and are not exposed to light. Apparently those washed out before hatching would not only be exposed to predation, but also to lethal light intensities. The greater hatching of eggs at 18°C may have been due to their being raised on a shelf farther from the light source than the 23°C experiments.

Three sets of eggs were run in fresh water at 23°C with 1, 2, 4, 8, 16, and 32 eggs per chamber. About half gastrulated with no regard to concentrations. All that gastrulated developed normally for 3 more days and then deaths began. Apparently the numbers of eggs enhanced survival as subsequent deaths averaged 5.5, 5.5, 6.5, 5.9, 5.9, and 6.8 days respectively.

Topsmelt, *Atherinops affinis*

Fertilized topsmelt eggs developed at all temperatures tested below 26.8°C (Figure 3). Although the eggs in both high temperature preparation dish experiments (28.5 and 31.0°C) gastrulated, the latter did not form a circulatory system and the former died shortly after circulatory formation. Therefore the maximum development temperature tolerance is probably between 27 and 28.5°C. The lower development temperature tolerance has not been ascertained; however, it must be not far below 12.8°C because death closely follows hatching at that temperature. The effects of temperature on development rate seem to be greater below 19°C than above. Hatching time doubles with each 5°C decrease below 19°C, while the development rate doubles with each 11°C increase above 19°C.

A preparation dish experiment at 21.0°C hatched in 11.3 days. The test tube experiments at 20.3 and 21.2°C hatched in 11.5 and 10.3 days respectively.

Mussel blenny, *Hypsoblennius* sp.

Blenny eggs hatched at both the warmest and coldest temperatures tested, 12.0 and 26.8°C. The irregular developmental rates (Figure 4) may be due to eggs being introduced into the experiments at varying developmental stages. Obviously, eggs exposed at later ontogenetic stages may hatch earlier than eggs exposed shortly after fertilization. Despite these serious handicaps, it is apparent that mussel blenny eggs hatch over a wide temperature range and that thermal effects on developmental rate are more pronounced at low temperatures. In this species the break appears to be at about 15 to 16°C.

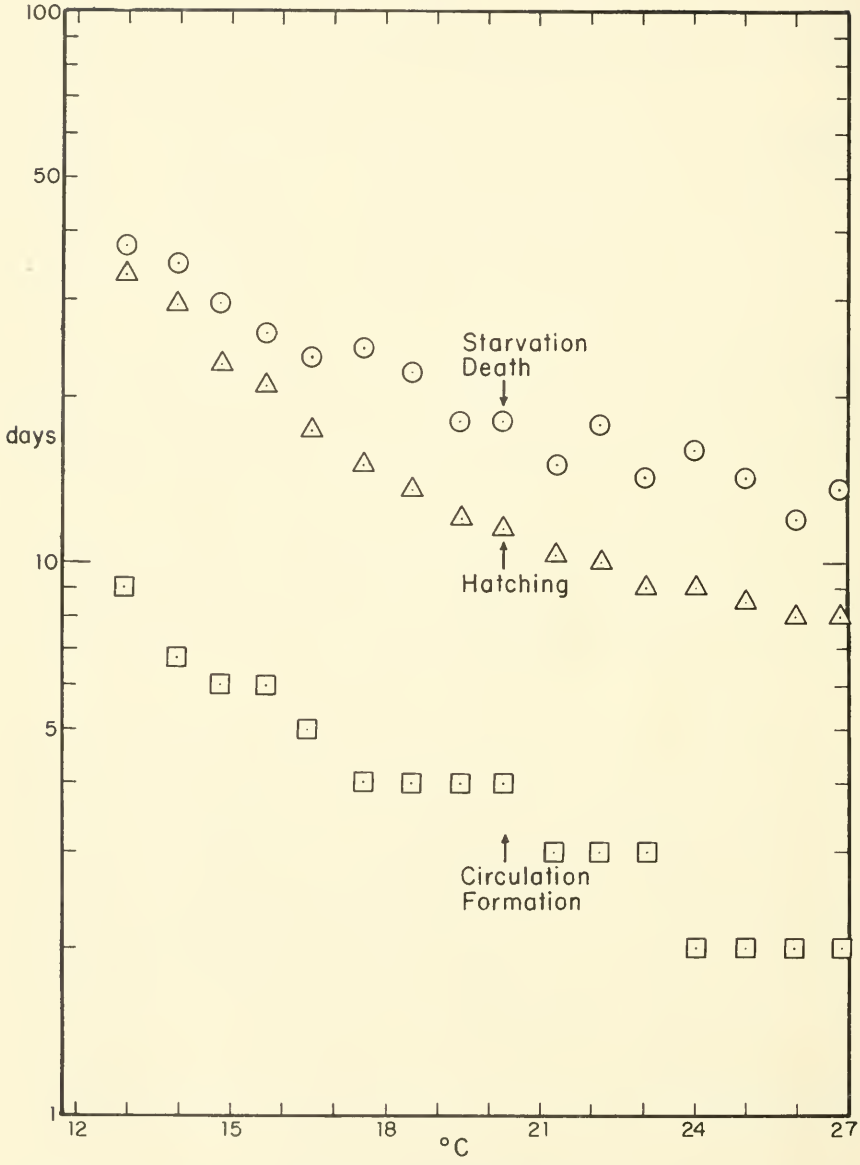

FIGURE 3. Average effects of temperature on development rates of topsmelt eggs exposed within 15 minutes of stripping.

DISCUSSION

The development temperature tolerance has been ascertained with assurance for California killifish and California grunion, and approximated for topsmelt and mussel blenny. The breeding seasons for these species started in late March, late February or early March, early February, and perhaps in February respectively in 1963, at La Jolla.

The start of the breeding season corresponds to the minimum hatching temperature for each species, 16.6°C, 14.8°C, 12.8(?)°C or lower, and 12.0°C or lower, respectively. The early spawners have eggs tolerant of colder temperatures. Likewise, wooly sculpin eggs consistently hatch at 11.1°C and this species bred at least as early as January, 1963. The maximum tolerations seem to reflect the same happenstance in that

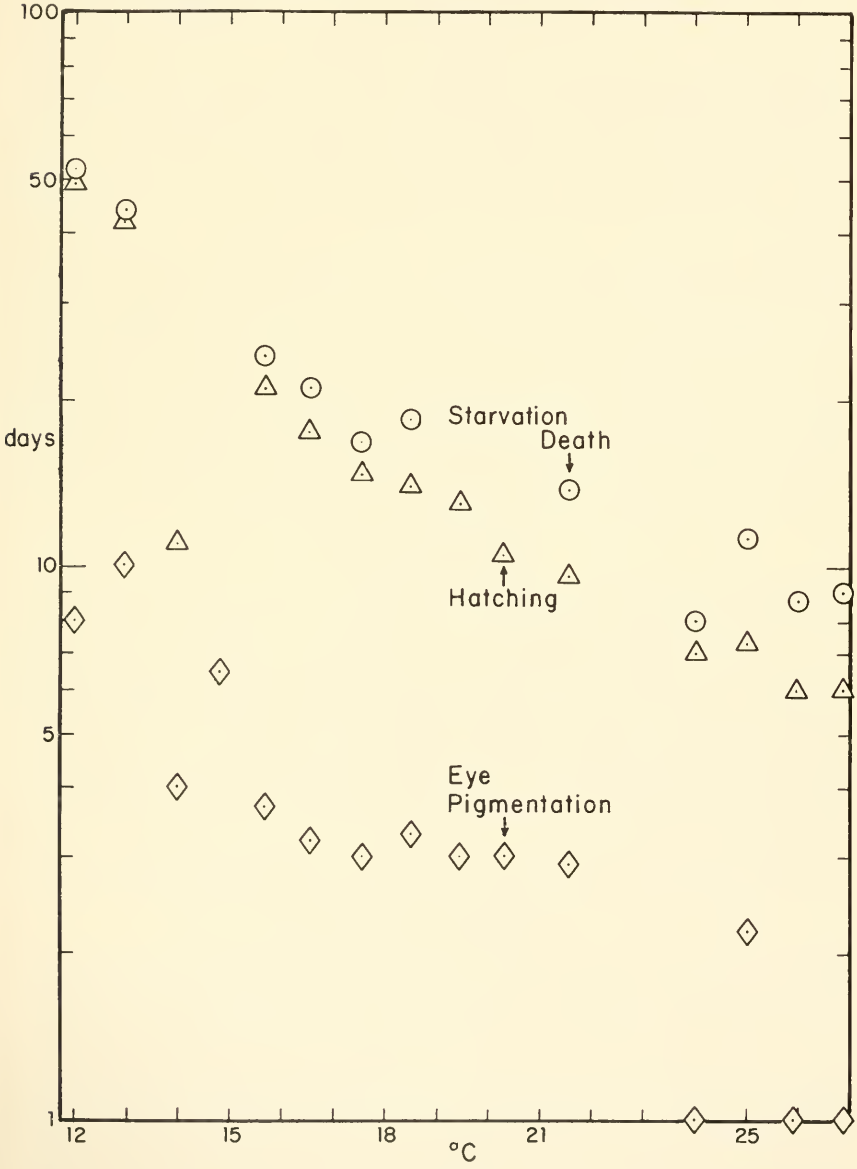

FIGURE 4. Average effects of temperature on development rates of naturally fertilized mussel blenny eggs.

killifish can withstand far higher temperatures than the others, although the end of the breeding seasons was not ascertained.

The developmental rates for all four species were far more modified by temperature change in cold water than they were in warm water. This change appears to be over a limited temperature range. Similar developmental breaks have been noted by Hubbs (ms) for wooly sculpin and Hubbs (1961) for greenthroat darter, *Ethcostoma lepidum*. Therefore those temperature breaks may be typical of developing fish eggs. It is possible that they reflect the same physiologic phenomena that caused the "V-shaped" vertebral responses to thermal conditions reported by Tåning (1952). These breaks correlate somewhat with breeding season; California killifish (21°C), California grunion (19°C), topsmelt (19°C), wooly sculpin (19°C), and mussel blenny (16°C). The correlation is not absolute, as the maximum toleration of wooly sculpin is lower (23°C) than that at which mussel blenny eggs will hatch.

Eggs of two species seemed to be affected by light. All of the killifish eggs in glass preparation dishes (in diurnal light) hatched before comparable test tube experiments (in nearly total darkness). Conversely grunion eggs in diurnal light had notably reduced hatching. Although some of the reduced hatching may have been due to crowding, those maintained at otherwise optimal temperatures seldom had hatching percentages in excess of 50 percent. Test tube experiments at the same temperatures typically had hatching percentages of 90 percent or greater. Adverse effects of light are not unexpected for a species that buries its eggs in the sand (Walker, 1952).

LITERATURE CITED

Hubbs, Clark. 1961. Differences in the incubation period of two populations of *Ethcostoma lepidum*. Copeia, 1961: 198-200.

_____. in press. Fertilization, initiation of cleavage, and developmental temperature tolerance of *Clinocottus analis*.

Lasker, Reuben. 1964. An experimental study of the effect of temperature on the incubation time, development, and growth of Pacific sardine *(Sardinops caerulea* Girard) embryos and larvae. Copeia, 1964: 399-405.

Strawn, Kirk, and C. Hubbs. 1956. Observations on stripping small fishes for experimental purposes. Copeia, 1956: 114-116.

Tåning, A. Vedel. 1952. Experimental study of meristic characters in fishes. Biol. Revs. Cambridge Phil. Soc., 27: 169-193.

Walker, Boyd W. 1952. A guide to the grunion. Calif. Fish and Game, 38(3): 409-420.

NOTES

THE OCCURRENCE OF WARMOUTH, *CHAENOBRYTTUS GULOSUS* (CUVIER), IN THE LOWER COLORADO RIVER

The Warmouth became a known member of the lower Colorado River fauna on July 31, 1961, when Shoken Sasaki of the California Department of Fish and Game captured a specimen in a seine directly below the Palo Verde Diversion Dam, 10 miles north of Blythe, California. Carl L. Hubbs, Scripps Institution of Oceanography, verified the identification.

Warden Larry Redfern, California Department of Fish and Game, made the first recorded angler catch on March 20, 1963, when he caught a warmouth about one-half mile above the 26th Avenue County Park, Blythe. Hubbs also verified this identification. Redfern reported the capture of two additional warmouth adjacent to Intake Boulevard, between 24th and 26th Avenues, 5 miles south of Blythe.

Two warmouth were taken in gill nets on May 8, 1964, on the Arizona side of the river, about 500 yards below the confluence of the Palo Verde Lagoon. Warmouth are apparently established in the lower Colorado River, but the source of introduction is unknown. Scales were removed from all specimens and used for determining ages.

Capture		*Length (cm)*			
Date	*Method*	*Total*	*Fork*	*Weight (g)*	*Age Group*
July 31, 1961	Seine	11.2	10.4	28	I
Mar. 20, 1963	Angling	19.0	18.3	170	II
July 3, 1963	Angling	17.9	17.0	111	--
Feb. 11, 1964	Angling	16.8	16.2	96	II
May 8, 1964	Gill net	15.2	--	57	II
May 8, 1964	Gill net	15.5	--	61	II

—*Roger Lanse, Inland Fisheries, Region 5, California Department of Fish and Game, November 1964.*

THE CLINGFISHES (GOBIESOCIDAE) OF GUADALUPE ISLAND, MEXICO[1]

Guadalupe Island is small, about 22 miles long and 4 to 6 miles wide, and located about 162 miles off the coast of northern Baja California opposite Punta Blanca. It is surrounded by deep water so that its shore fauna is fairly well isolated from that of the mainland.

Hubbs and Rechnitzer (1958) spoke of a "high incidence" of endemism in the littoral marine fauna of Guadalupe Island. Despite repeated collections made since 1945, the fish fauna is still poorly known

[1] Research supported by National Science Foundation Grant GB-2836.

because very little work has been done on the material. Briggs (1955) described two new clingfishes, *Gobiesox eugrammus* and *Rimicola sila,* from specimens collected by Carl L. Hubbs. Hubbs and Rechnitzer (1958) in describing a new butterfly fish, *Chaetodon falcifer,* from the island, did give a list of 33 other species that occurred in the same collection.

In the course of examining unidentified clingfish material from the Scripps Institution of Oceanography collection, two specimens were found that help to clarify our knowledge of the geographical relationship of the Guadalupe marine fauna. First, a large, 35.3 mm *Gobiesox eugrammus* (SIO 59-307) was discovered that had been taken on 10 August 1959 from the south side of Papalote Bay, Punta Banda, Baja California, over a rock and sand bottom with depths up to 35 feet. The specimen was captured by divers from Scripps who were using rotenone to collect fish. Second, a young, 17.6 mm *G. rhessodon* Rosa Smith (SIO 60-15) was found that had been taken from a tidepool about 1 mile north of Barracks Cove, Guadalupe Island, on 27 January 1960. This specimen was also captured by a group from Scripps using rotenone to collect.

The discovery of the common mainland species, *G. rhessodon,* at Guadalupe Island and the finding of the previously held Guadalupe endemic, *G. eugrammus,* along the mainland shore, alters to some extent the supposed faunal relationship between the two areas. The Guadalupe clingfish fauna may now be said to consist of three species but only one (*Rimicola sila*) can still be classed as an endemic.

Although a fairly large number of shore fishes were at one time thought to be Guadalupe Island endemics, it is interesting to see that many of them, including *Chaetodon falcifer* (Hubbs, 1960) have since been taken elsewhere. In fact, only about four or five species can still be considered well-defined endemics.

Thanks to the work of Strong and Hanna (1930), Strong (1954), and Chace (1958) the mollusks are better known than any other component of the marine fauna of Guadalupe Island. Chace listed a total of 193 species with 149 or 77.2 percent belonging to the southern California fauna, 34 or 17.6 percent belonging to the Panamic fauna, and 10 or 5.2 percent endemic.

Considering that so few fish species have, thus far, proven to be endemics and that the autochthonous mollusks make up a relatively small part of their group, Guadalupe Island must be considered an integral part of the California Warm-Temperate Zoogeographic Region (the San Diegan fauna of Hubbs, 1960). The low incidence of endemism seems proportionate to the degree of spatial isolation. To the south, other offshore islands (Revillagigedos, Clipperton, Cocos, Galapagos) demonstrate higher rates of endemism but they are also better isolated.

LITERATURE CITED

Briggs, John C. 1955. A monograph of the clingfishes (order Xenopterygii). Stanford Ichthy. Bull., 6 :1-224, 114 figs.

Chace, E. P. 1958. The marine molluscan fauna of Guadalupe Island, Mexico. Trans. San Diego Soc. Nat. Hist., 12(19) : 319-332, 1 fig.

Hubbs, Carl L. 1960. The marine vertebrates of the outer coast *in* symposium: the biogeography of Baja California and adjacent seas. Syst. Zool., 9(3-4): 134-147.

Hubbs, Carl L. and Andreas B. Rechnitzer. 1958. A new fish, *Chaetodon falcifer*, from Guadalupe Island, Baja California, with notes on related species. Proc. Calif. Acad. Sci., 29(8) : 273-313, 3 pls.
Strong, A. M. 1954. The marine molluscan fauna of Guadalupe Island, Mexico. Min. Conch. Club So. Calif., (142) : 6-10 (not seen).
Strong, A. M. and G. D. Hanna, 1930. Marine Mollusca of Guadalupe Island, Mexico. Proc. Calif. Acad. Sci., 19(1) : 1-7.

—*John C. Briggs, Department of Zoology, University of South Florida, Tampa, Florida 33620. December 1964.*

RANGE EXTENSION FOR THE BIGMOUTH SOLE, *HIPPOGLOSSINA STOMATA*

The known geographical range for the bigmouth sole was extended northward about 130 miles on October 22, 1964, when a 13-inch specimen was taken in an otter trawl fished from the vessel *Three Sisters* in 45 fathoms off the Salinas River, Monterey Bay. When the catch, chiefly English sole *(Parophrys vetulus)*, was unloaded at Regal Seafood Co., Monterey, marketman Edwin Low noticed the unfamiliar specimen and saved it for identification.

Although the range for this species has been listed as Point Conception south into the Gulf of California (Roedel, 1953), Ginsburg (1952), in reviewing the genus, did not report any specimens south of Ballenas Bay, Baja California, but he did have material from off Cape Tepoca, northern Gulf of California. Ginsburg gave the maximum size of *H. stomata* as 334 mm TL (13 inches), and the maximum depth of capture as 74 fathoms.

Based upon California Department of Fish and Game records (J. E. Fitch, pers. comm.) the species has not been taken south of Magdalena Bay, Baja California, on the outer coast, nor has it been captured in the southern Gulf of California. In April 1964, the Department's research vessel *Alaska* captured many *H. stomata* and a few *H. tetrophthalmus* during trawling operations in depths of 45 to 55 fathoms in the northern Gulf of California, mostly between Las Animas Bay and Santa Inez Bay. The depth record was increased to 100 fathoms on January 17, 1959, when the Department's research vessel *N. B. Scofield* captured eight bigmouth sole in an otter trawl fished 9.5 miles NNW of Cedros Island, Baja California. Most of these fish, including a ripe female 308 mm TL (12 inches), had recently fed upon pelagic red crabs, *Pleuroncodes planipes*.

A new maximum size for *H. stomata* was recorded in May 1954 when a 357 mm TL (14 inches) female, was caught on hook and line at the Coronado Islands, Baja California. This fish weighed 450 grams (J. E. Fitch, pers. comm.).

Thus, based on information that has become available since Ginsburg (1952) and Roedel (1953) published accounts of *H. stomata*, its maximum size and vertical distribution have been extended, and its geographical distribution has been more clearly defined.

REFERENCES

Ginsburg, Isaac. 1952. Flounders of the genus *Paralichthys* and related genera in American waters. U.S. Fish & Wildl. Serv., Fish. Bull., 52(71) : 265-351.

Roedel, Phil M. 1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull., (91) : 184 p.

—J. B. Phillips, Marine Resources Operations, California Department of Fish and Game, December 1964.

AN AMBICOLORED STARRY FLOUNDER FROM YAQUINA BAY, OREGON[1]

ALAN J. BEARDSLEY and HOWARD F. HORTON

An ambicolored starry flounder *(Platichthys stellatus)* 22.4 cm SL was captured in Yaquina Bay, Oregon, on September 24, 1964. This is the second known occurrence of an ambicolored starry flounder (Gudger, 1941), and the first for which photographs are available. The fish is now catalogued as OS 1343 in the ichthyological collection of the Department of Fisheries and Wildlife at Oregon State University.

Fin-ray counts were within the normal range listed for the species by Clemens and Wilby (1961): dorsal, 64; anal, 45; and pelvic, 6. On the blind and normally white side of the fish, brownish-black pig-

[1] Financed in part by the Tiburon Marine Laboratory, U.S. Fish and Wildlife Service, Tiburon, California.

FIGURE 1. Blind side of the ambicolored starry flounder from Yaquina Bay, Oregon. *Photograph by William M. Reasons, October 1964.*

mentation occurred on all but the anterior one-third of the head and leading edge of the pectoral fin (Figure 1). The lips are dark and the mouth is symmetrical, also anomalous conditions. Of significance is the incompletely rotated left eye, and the dorsal fin which is hooked slightly at the anterior end. These anomalies are apparently common for ambicolored flounders of all species (Gudger, 1941). The ocular side of the specimen possesses normal coloration.

Norman (1934) has said that areas on the head or body of flatfish devoid of pigment (piebald) frequently follow an injury, especially one affecting the vertebral column. An X-ray photograph of the specimen was prepared to see if vertebral damage was present and as such might offer an explanation for the ambicoloration. Comparisons were made with a similar photograph of a normal flounder and with that of a piebald starry flounder published by Follett (1954). Vertebral damage was absent from both the ambicolored and the normal flounder. Differences in spinal curvature, dorsal silhouettes, and relative size of the pharynx were also apparent in the X-rays, although these variations could possibly occur between two normally pigmented fish.

Spinous stellate plates, responsible for the roughness of starry flounders, are usually not as prevalent on the blind as on the ocular side. On our specimen, these bony tubercles appear extensively on the blind side and extend well onto the head region, seemingly related to the absence or presence of pigmentation (Figure 1).

In the period from 1815 to 1963, some 30 references are on record of abnormal coloration in flatfishes from American waters (Dawson, 1962; Fitch, 1963). Dawson reported on more than 39 specimens, possessing eight anomalous conditions, and Fitch mentioned that either partially- or fully-ambicolored individuals had been noted among all species of *Pleuronichthys* except *ocellatus*. Only two of these reports pertained to anomalous starry flounders; Orcutt (1950) did not mention ambicoloration in his comprehensive treatment of the life history of the species.

Gudger (1941) reported a totally ambicolored starry flounder caught by Carl L. Hubbs 15 or 20 miles off Petersberg, Alaska. It was truly ambicolored, as dark on one side as the other, and measured 12½ inches (31.3 cm) TL. The left eye of the flounder had rotated barely over the median ridge and was accompanied by a dorsal fin hooked at the anterior part. According to Gudger (1941), his was the first ambicolored starry flounder ever reported or described. Unfortunately, the head and abdomen of the fish were cut badly in the process of freezing and no pictures were taken.

Follett (1954) reported a starry flounder which had irregular white blotches on the ocular side, principally on the caudal peduncle and elsewhere over the posterior one-third of the body. His published X-ray revealed a developmental abnormality or injury affecting the 22nd and 23rd caudal vertebrae, which had the appearance of having been driven together.

These anomalous conditions are probably due either to mutations or to external influences prior to metamorphosis. Perhaps a correlation exists between eye migration and the melanistic side. This could explain

pigmentation occurring on both sides of the flounder due to the incomplete migration of the eye.

REFERENCES

Clemens, W. A., and G. V. Wilby. 1961. Fishes of the Pacific Coast of Canada (2nd ed.). Fish. Res. Bd. Canada, Bull., (68) : 443p.

Dawson, C. E. 1962. Notes on anomalous American Heterosomata with descriptions of five new records. Copeia, 1962 (1) : 138-146.

Fitch, John E. 1963. A review of the fishes of the genus *Pleuronichthys*. Los Angeles County Museum, Contr. In Sci., (76) : 33p.

Follett, W. I. 1954. The case of the piebald flounder. Pacific Discovery, 7(5) : 24–25.

Gudger, E. W. 1941. A totally ambicolorate flounder, *Platichthys stellatus*, from Alaskan waters. Copeia, 1941 (1) : 28-30.

Norman, J. R., 1935. A systematic monograph of the flatfishes (Heterosomata). Brit. Mus. Nat. Hist., 1 : 459p.

Orcutt, Harold G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Div. Fish and Game, Fish Bull., (78) : 64p.

—*Alan J. Beardsley and Howard F. Horton, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, December, 1964.*

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Notice is hereby given that the Fish and Game Commission shall meet on April 2, 1965, at 10 a.m., in the new State Building, 107 South Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the Department and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, orders should be made relating to birds or mammals, or any species or variety thereof, in accordance with Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, pursuant to Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet at 10 a.m., on April 23, 1965, in the Supervisors' Chamber, County Courthouse, Room 21, Redding, California, for public discussion of, and presentation of objections to, the proposals presented to the Commission in April and, after considering such discussion and objections, the Commission shall publicly announce the regulations it proposes to make relating to birds or mammals, or any species or variety thereof for the 1965 hunting season.

FISH AND GAME COMMISSION
Monica O'Brien

Notice is hereby given that the Fish and Game Commission shall meet on May 28, 1965, at 10 a.m., in the Auditorium, Resources Building, Ninth and O Streets, Sacramento, California, to hear and consider any objections to its determinations or proposed orders in relation to birds and mammals for the 1965 hunting season, such determinations resulting from hearing held on April 23, 1965. This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Monica O'Brien

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